RUSS OLSON VOLUME 5

POWER GENERATION AND DISTRIBUTION

Sub-divisions Within This Volume

- (Contents of the Entire Binder)

POWER GENERATION AND DISTRIBUTION

CABLECAR POWERHOUSES

Selby Ave. Cable Powerhouse
St.Paul
1887-1898

Two E.P. Allis Company 28" x 60" Reynolds-Corliss Engines rated at 500 h.p. each (550 h.p. per a Street Railway Journal advertisment). One installed in 1887 and one in 1888.
Four Wood oil-burning Boilers rated at 150 h.p. each.
Two sets of Cable Winding machinery.
One Westinghouse 35 KW Lighting set (35 h.p. engine).

During electrification of the horsecar system one of the Allis Engines was borrowed for use in a temporary installation during 1890-1891 at the new Hill St. Powerhouse under construction.

The "Electric Extension of the Selby Avenue Cable Line" opened 9-25-1891. The cable terminal was moved back from Fairview Ave. to Chatsworth St. and that trackage converted to electric operation, completed 10-14-1891. It is assumed that electricity for this line was generated by this powerhouse; no specific mention has been found so far.

The "Selby Avenue" cable line ceased operating 6-3-1898 and was replaced by an electric line and Selby Hill counterweight system, beginning 8-3-1898. The Selby Ave. carhouse was converted for electric car operation so it is again assumed that electricity for the "Selby Ave." line continued to be generated by this powerhouse. We have found no record of the disposition of the cable machinery. Its further history an electric powerhouse is related separately on subsequent pages.

E. 7th St. Cable Powerhouse
St.Paul
1889-1893

There are three versions as to the cable powerhouse machinery.

June 1889 American Railway Journal:
  two Reynolds-Corliss Engines rated at 450 h.p. each,
  three Babcock & Wilcox Boilers, and
  one Robert Poole cable driving Engine.
Trumbull 1893 Inspection Report:
  one Allis single-cylinder non-condensing Corliss Engine rated at 600 h.p.,
  three Boilers rated at 150 h.p. each,
  one Westinghouse 35 h.p. Engine for lighting, and
  one set of cable winding machinery.
A. L. Drum & Company Valuation Report:
  two E. P. Allis Company 28" x 60" Reynolds-Corliss Engines (rated at 550 h.p. each per a Street Railway Journal advertisment),
  three Babcock & Wilcox Boilers rated at 208 h.p. each,
  one Westinghouse 35 KW Lighting set, and
  two sets cable winding machinery.

During electrification of the horsecar system, one of the Allis Engines was borrowed for use in a temporary installation at the Hill Street Station of the St.Paul Gas Light Co.

The "East 7th Street" cablecar line was converted to electric operation 9-1-1893. The E. 7th St. carhouse was converted to electric operation. Subsequenty the engine room machinery was removed and the space rebuilt into a three-track carhouse. There is no record of this facility generating electricity for the electric lines and no record of the disposition of the cable powerhouse machinery.

Both Cable Powerhouses

An 1892 Street Railway Journal advertisement lists two orders for 11 Boilers during 1888-1890, 2800 h.p. total, from Babcock & Wilcox, all for the cable system.

ELECTRIC POWERHOUSES

The generating machinery for the first experimental electric line in Minneapolis was installed on a temporary basis in the machine shop of Otis A. Pray, proprietor of The Consolidated Minneapolis and Minnesota Iron Works, located at 5th Ave. S. and 1st St. S.

O. A. Pray & Company was organized 6-1-1878 by Mr. Pray who in 1876 had acquired the Minneapolis Iron Works, a manufacturer of mill furnishings and millwright goods. He acquired property at 5th Ave. S. and 1st St. S. and began the erection of a new foundry and machine shop for the manufacture of heavy iron goods. He also purchased new tools and machinery and had the only machinery in the west for regrinding crusher rolls. The new facilities comprised the following.

Two-story stone building 35' x 95' fronting on 5th Ave. S. The first floor was for offices and the second floor for ware rooms.
A large fireproof vault adjoining the office to store bolting cloth.
Three-story brick warehouse 32' x 330'.
Two one-story brick machine shop buildings: 50' x 100'; and 50' x 65' for woodworking.
Stone building 60' x 80'used as a foundry and blacksmith shop.

The C.M.&St.P. RR. constructed three side tracks into the facility.

The generating machinery consisted of:
one Russell & Company (Massillon, Ohio) 250 h.p. Engine,
one Hazelton "Porcupine" Boiler, and
three compound-wound 80 h.p. Generators.

The A. L. Drum & Co. Valuation Report listed two Thomson-Houston D-62 Generators. used during 1889 and 1890 until Power Station #1 was completed.

Mpls. Tribune 6-21-1890
MSR has added one
extra engine of 80 HP
to the powerhouse.
This makes a total
of 330 HP.

250
80

In St.Paul, the St.Paul Gas Light Company during 1885 built an electricity generating plant, the Hill Street Station, at Hill St. and Ontario St. For the first electric line in St.Paul, a temporary installation of generating machinery was installed in this plant during late 1889.

One Allis 28" x 60" Corliss Engine borrowed from the E. 7th St. Cable Powerhouse. This was returned when the temporary plant was relocated to the new SPCR Hill St. Powerhouse in 1890.
Two Thomson-Houston D-2 Generators rated at 150 KW each.

Once electrification of the horsecar systems in both cities had been approved by the respective city councils, work began on the construction of a major power station in each city. At this time the method of power generation consisted of steam-powered fly-wheel engines belted through jack-shafts to direct current generators supplying direct current directly to the trolley wires.

Power Station #1
Main Central Powerhouse
Minneapolis

This was located in a three-story brick addition, 180' x 199', to the existing carhouse-office building at 3rd Ave. N. and 2nd St. N., completed during 1890. This addition had been intended as one of the powerhouses for the proposed cablecar system. A tunnel was constructed under 3rd Ave. N. and the railroad tracks to the Mississippi River to insure an ample supply of water in case of water main breakage or failure of the city water supply. This tunnel was of brick construction, 8' square by 1500' long. Refer to the Chapter on CARHOUSES AND SHOPS for drawings and specific measurements.

The powerhouse machinery consisted of the following.
Two E. P. Allis & Co. Reynolds-Corliss triple expansion (24" x 40" x 56" x 60") condensing Engines rated at 1250 h.p. each.
One E. P. Allis & Co. Corliss single cylinder (28" x 60") condensing Engine rated at 600 h.p. It was later compounded to 17" x 28" x 60".
Two Stirling Boilers (crude oil fired) rated at 287 h.p. each.
Five Babcock & Wilcox Boilers (crude oil fired) rated at 272 h.p. each (ordered September 1889 for the proposed cablecar system).
The total rated Boiler capacity was 1,935 h.p.
There are two versions as to the Generators.
Trumbull 1893 Inspection Report:
17 Edison #60 bi-polar (225 h.p., 500 volts D.C.) Generators rated at 175 KW each.
One 100 arc light machine.
A. L. Drum & Co. Valuation Report:
12 Generators rated at 150 KW each (one for the 150 arc light machine) = 1800 KW
5 Generators rated at 175 KW each = 875 KW
1 Generator rated at 100 KW each (one for the 100 arc light machine) = 100 KW
2 Bain Generators rated at 90 KW each = 180 KW
Total rated capacity 2955 KW
=======

The Engines were connected to the main line-shaft with 55" wide, three-ply, leather belts.

Underground conduit and cable were installed during 1890 on 3rd Ave. N., Washington Ave. N. and S., and 1st Ave. S. These were removed about 1898 after installation of the Lower Dam Hydro-Electric Station.

This powerhouse became a standby plant in 1898 after completion of the Lower Dam Hydro-Electric Station since the flow of the Mississippi River was seasonally variable.

To provide additional capacity pending completion of the new Main Steam Station, a temporary extension was made during 1902. This work consisted of adding the following equipment.
One Allis Corliss compound (26" x 40" x 48") Engine.
One Buckeye tandem compound (24" x 48" x 48") Engine.
Four Babcock & Wilcox Boilers rated at 556 h.p. each, 2,224 h.p. total.
Three General Electric Co. 600 KW Rotary Converters from Substation #1 were belted and driven as Generators. Rated at 75% of normal capacity: 1800 KW at 75% or 1350 KW.

After completion of the new Main Steam Station in December 1903, this powerhouse was taken out of service. The Construction Journals for May 1904 indicated that three of the 1902 Babcock & Wilcox 556 h.p. Boilers had been relocated in April to the Main Steam Station. The fourth was also relocated there and all four were installed during July 1904. Dismantling of the power house machinery began in 1906. The Construction Journals record some of the machinery dispositions.

July 1906: one old Engine sold.
1906: two 175 KW Generators sold to Duluth Street Railway.
December 1906 thru February 1907: four Babcock & Wilcox Boilers were moved to the Snelling Shops.
August 1907: one Allis Engine and several Generators sold.
June 1908: one Buckeye Engine and seven Babcock & Wilcox 240 h.p. Boilers were sold.
1909: two Allis Engines traded to Allis-Chalmers for streetcar airbrake equipment.
Dismantling was completed between November 1908 and November 1909. The building and real estate were sold in December 1908 to W. B. and W. G. Jordan.

Hill Street Powerhouse
St.Paul

In St.Paul the main powerhouse was built on Hill st. near W. 3rd St. (now Kellogg Blvd.) opposite the electric plant of the St.Paul Gas Light Company. It was a three-story brick building measuring 137' x 145'. The A. L. Drum & Co. Valuation Report gives the following dimensions.
two-story, brick: front 137'0"; rear 62'8" on Spring St., 161'6" on Ontario St.; east end 144'9".
Note that the drawing gives still different dimensions.

A temporary electric plant was installed here during 1890. Equipment consisted of the following.
One E. P. Allis Co. 28" x 60" Reynolds-Corliss Engine temporarily borrowed from the Selby Ave. cablecar powerhouse. It was returned when the completed Hill St. facility opened during 1891.
Two Thomson-Houston D-2 Generators from the temporary plant in the St.Paul Gas Light Co. building.

Full operation was attained by September 1891; as completed supplied electricity for all St.Paul lines, the Interurban line, and some Minneapolis lines. Equipment comprised the following.
Three E. P. Allis Co. triple expansion (24" x 40" x 56" x 48") Reynolds-Corliss condensing Engines rated at 1000 h.p. each.
Six Babcock & Wilcox Boilers rated at 272 h.p. each for a total of 1,632 h.p. According to a Street Railway Journal advertisement 8 Boilers (272 h.p.) had been ordered in April 1890.
One Buckeye Engine rated at 200 h.p. for one 100 arc light machine.
Fourteen Generators rated at 150 KW each for a total of 2100 KW.
Three Excelsior Light Machines (one 150 light, one 100 light and one 50 light), total 150 KW.
Total plant capacity: 2250 KW.
The brick smokestack was 200 ft. high. The Trumbull 1893 Inspection Report listed 16 Edison Dynamos rated at 175 h.p. (sic) each and one Thomson-Houston Generator rated at 100 h.p. (sic).

One source states that the boilers were crude oil fired while another says that both coal and crude oil were used. Frank Trumbull's 1893 Inspection Report stated that he felt the arrangement of the Hill St. Powerhouse was superior.

This facility became a standby plant in 1898 after completion of the Lower Dam Hydro-Electric Station in Minneapolis. The Construction Journals record expenditure of $5,273 on steam equipment (no detailed description) from December 1901 thru April 1902. It was probably taken out of service in 1904 after completion of the Main Steam Station in Minneapolis.

Accounting records indicate the equipment was dismantled and removed from November 1908 through November 1909. Recorded dispositions were:
1909: Engines and pulleys sold to North American Lead Company.
September 1909: two Engines sold to Manufacturers Supply Company.
November 1909: thirteen Generators sold to St.Paul Scrap Iron & Metal Company.
The building and real estate were sold August 1909 to the St.Paul Gas Light Company.

Power Station #2
31st St. and Nicollet Ave. S.
Minneapolis

This was originally intended to be one of the cable powerhouses for the proposed cablecar system. Instead it was built as an "auxiliary" powerhouse for the electric railway sytem. Construction began during 1891 and was completed in May 1892. This station supplied electricity for all Minneapolis lines south of Washington Ave. and east of Nicollet Ave. According to the Trumbull 1893 Inspection Report equipment comprised the following.

10 Westinghouse compound non-condensing Engines rated at 250 h.p. each.
7 Stirling Boilers (160 p.s.i.)(crude oil fired) rated at 287 h.p. each. Total 2,009 h.p.

9 Thomson-Houston Multi-Polar Generators rated at 250 KW each	=	2250 KW
1 100 arc light machine	=	250 KW
Total capacity	=	2500 KW

1 exciter Generator.

The A. L. Drum & Co. Valuation Report listed 10 Westinghouse Engines rated at 260 h.p. each, 5 Stirling Boilers rated at 287 h.p. each, and 10 Thomson-Houston M.P. Generators rated at 250 KW each for a total capacity of 2500 KW.

The powerhouse was taken out of service in 1897 or 1898 after the Lower Dam Water Power Station was placed in operation. The Construction Journals begin in 1900 and there is no record of disposition of any of this powerhouse equipment from that date onward.

Selby Ave. Powerhouse
St.Paul

A company bulletin stated that the powerhouse machinery was rebuilt during 1902 and placed back in service December 17, 1902. The Construction Journals indicate this was a temporary installation similar to that at 3rd Ave. N. in Minneapolis. Building alterations began in ~~Juon~~ June 1902. Expenditures incurred from June 1902 through February 1903 were as follows.

Building alterations	$ 1,658
Steam Equipment: one Engine and two Boilers	$17,422
Electric Equipment: no details provided	$ 3,793
Total	$22,873

Both Boilers were removed during May 1904 and reinstalled at the new Main Steam Station in Minneapolis. The one engine was sold in July 1907.

Storage Battery Plants

Two storage battery plants, each with one chloride battery, 288 cells, 1,600 amp-hour capacity, together with a booster and switchboard, were placed in operation during 1901-1902.

The Minneapolis plant was located in the Main Central Powerhouse at 3rd Ave. N., installed 1901.

The St.Paul plant was installed during 1902 in a building purchased during 1901 on 10th St. near St.Peter St. adjacent to St.Joseph's Hospital. This was a two-story and basement, stone building 99' x 150'. It was divided into three 33' x 150' sections by stone firewalls. (Wood floors.)

The equipment from each plant was moved to new locations during 1904. The Minneapolis equipment went to the new 11th St. Substation and the St.Paul equipment to the new College Ave. Substation.

Both storage battery plants were taken out of service in 1912 and dismantled during 1912-1913.

Minneapolis & St.Paul Suburban Railway
Stillwater Division

The purchase of the St.Paul & Suburban Railway in 1898 included one steam powerhouse located in North St.Paul. The extension of the line from Wildwood to Stillwater during 1899 resulted in construction of a steam powerhouse (coal fired) at Wildwood. The construction of the street railway system in Stillwater apparently re-used the former Stillwater St. Ry. steam powerhouse.

North St.Paul

Built during 1892 by the St.Paul & White Bear Railroad located at Pennsylvania St. and the right-of-way in an 86' x 122' building which also contained the carhouse. Street Railway Journal advertisements reported that two Babcock & Wilcox Boilers rated at 92 h.p. each were ordered in March 1892. No information as to the Engine and Generators, except that the latter were manufactured by the Thomson-Houston Co. as the Northwest Thomson-Houston Co. electrified the railway. Coal was probably hauled from the interchange with the C.St.P.M.&O Ry. in Hazel Park with the ex-North St.Paul Railroad steam motor. Taken out of service during 1904. The two Boilers were sold in January 1907. No disposition recorded as to the Engine and Generators. The real estate and building were sold in April 1908.

See Page 11A

Wildwood

The 75' x 130' building was constructed during 1899 together with an artesian well 569 ft. deep. The equipment consisted of: one Corliss Engine, an unspecified number of Boilers, and two Generators. Coal was hauled from an interchange with the Northern Pacific Ry. at Mahtomedi, probably with the ex-North St.Paul Railroad steam motor. The steam plant was taken out of service in 1904 and converted into a substation. Belting was sold in April 1909 but the steam equipment remained intact until dismantled during 1912.

Stillwater

The Stillwater Street Railway powerhouse-carhouse was built in 1889 located on N. Main St. between Mulberry St. and Linden St. Equipment consisted of: one Meyer fixed cut-off Engine rated at 125 h.p., an unspecified number of Boilers, and two Generators rated at 60 h.p. each. The successor Stillwater Electric Street Railway was to be abandoned in April 1897. It is unknown if the machinery remained intact or was sold in liquidation. We do know that Thomas Lowry purchased the real estate and building and resold it to the Mpls. & St.Paul Suburban Ry. in 1899. Mpls. St. Ry. and St.Paul City Ry. at this time had surplus powerhouse equipment that could have been re-installed here as well as at Wildwood. The steam plant was taken out of service in 1904. The equipment remained intact until dismantled in 1912 when the property was sold.

Hydro-Electric Power

With continued growth of the system, planning was initiated during 1895 to develop an additional source of power. Alternating Current distribution systems had been recently developed so TCRT decided to utilize A.C. distribution with the electricty generated by water-powered turbines operated by the flow of the Mississippi River. A contract was signed December 5, 1896 with the St.Anthony Falls Water Power Co. for the purchase of electric power. A brief history of water power generation at St.Anthony Falls is presented first before the discussion of the facilities at the Falls.

ST. ANTHONY FALLS

MINNEAPOLIS MILL COMPANY

Incorporated 2-27-1856; provider of water power on the west bank of the Mississippi River. Had water rights to the western channel and to the midpoint of the main stream.

	Owners	1860's
Cadwallader C. Washburn (President 1881; died 1882)	18.75%	62.50%
William D. Washburn (younger brother of C.C.Washburn)	18.75%	18.75%
Dorilus Morrison (cousin of C.C. Washburn)	18.75%	18.75%
Others	43.75%	

Suffered somewhat, but not greatly, during the 1873-1877 financial recession. The Washburn family made cash advances to the company.

Between 1876 and 1880 purchased all the sawmills because they were using water wastefully and posed a constant threat to the safety of the falls. The company also became a lumber mill operator, known as the Platform Mills.

ST. ANTHONY FALLS WATER POWER COMPANY

Incorporated 2-26-1856; water power provider on the east bank of the Mississippi River. Had water rights to the eastern channel and the other half of the main stream. The first officers were Franklin Steele, President, and Richard Chute, Secretary and Treasurer. Capitalized at $160,000 which was increased to $640,000 in 1875.

Henry G. Sidle, banker, was Treasurer in 1868. Early considerable stockholder conflicts resulted in financial difficulties and lack of progress. This was the main reason for St.Anthony merging with Minneapolis in 1872.

On March 1, 1880, or April 16, 1880, the company was purchased for $425,000 by a syndicate formed by some of the principal stockholders of the St.Paul, Minneapolis & Manitoba Railway. Officers were R. B. Angus, President; Edward Sawyer, Secretary and Treasurer; Directors were Angus, Sawyer and James J. Hill. Hill owned 50% of the company. The syndicate also paid $42,500 to W. W. Eastman for a few privileges not controlled by the Water Power Co. The railway wanted to bridge the Mississippi River and build a west bank depot. Hill became the major stockholder and President by 1882. The Board of Directors were all Hill associates in the St.PM&M Ry. Sawmill row was destroyed by fire in 1887.

PILLSBURY-WASHBURN FLOUR MILLS COMPANY LTD.

Incorporated in 1889 by members of the Washburn Mill Company, C. A. Pillsbury and Company, and a group of British capitalists. During 1889 purchased the Minneapolis Mill Company and the St.Anthony Falls Water Power Company, which became wholly-owned subsidiaries. Charles A. Pillsbury was chairman of the company's local management committee. Its other properties included five flour mills (one-third of the city's flour production capacity), two grain elevator companies, and various country elevators.

The Minneapolis General Electric Company had acquired the Minnesota Brush Electric Company, West Side Power Company, Minneapolis Electric Light & Power Company, and the franchises and properties of the Edison Light & Power Company of Minneapolis. During 1894-1895 the company built the Main Street Station on the east bank of the river; 8,000 h.p. total capacity of which 3,000 h.p. was provided by water power. (The plant was taken out of service in the 1960's. The building still exists as of 1998.)

The company built the Lower Dam during 1895-1897 at a total cost of $953,332 which included the water power station. The dam was built 2200 feet below the falls at an angle that diverted river flow toward the eastern shore. The power station was located on the dam's eastern end and equipped to convert 10,000 h.p. into electricity. (Ceremony 3-20-1897.)

The company built the Hennepin Island water power station during 1906-1908 at a total cost of $317,265. It was designed to operate entirely on surplus water such as was available during times of high water. Water was drawn from the St.Anthony mill pond thru a 350 ft. canal and returned to the river below the falls via a long tailrace. The station was leased 10-1-1907 to the Minneapolis General Electric Co. for 25 years at an annual rental of $75,000. The station was promptly sub-leased to the Twin City Rapid Transit Company.

The total installed capacity as of 1908 consisted of:

three hydro-electric plants (one Mpls. G.E. Co., two T.C.R.T. Co.) about	25,000 h.p.
flour mills	24,000 h.p.
North Star Woolen Mill, City of Minneapolis Hennepin Island Pumping Station, and others	6,068 h.p.
Total	55,068 h.p.

However the company suffered a financial collapse during 1908 caused by (1) declining profits from flour milling, and (2) failure of a wheat speculation venture secretly undertaken by members of the local management committee. It owed over $1 million it could not repay and went into receivership.

PILLSBURY FLOUR MILLS COMPANY

This company leased all of Pillsbury-Washburn Flour Mills Company's flour mills. It subsequently acquired the Minneapolis Mill Co. and the St.Anthony Falls Water Power Co.

NORTHERN STATES POWER COMPANY

This was a 1916 name change of Consumers Power Company which was controlled by H.M. Byllesby And Company, Chicago. It had acquired the Minneapolis General Electric Co. in 1912. The company had power plants located at St.Paul, Stillwater, Faribault, Mankato, Coon Rapids, and St.Croix Falls, Wisconsin. The St.Paul Gas Light Company was purchased in 1925.

Northern States Securities Corporation, a subsidiary of N.S.P. Co. purchased the Minneapolis Mill Co. and the St.Anthony Falls Water Power Co. from Pillsbury Flour Mills Co. in 1923 for $3 million. The latter two corporations were dissolved in 1957 to become the Hydro Division of N.S.P. Co.

Minneapolis Mill Company

The only joint venture carried out with the St.Anthony Falls Water Power Company was the construction of the St. Anthony Falls Dam during 1856-1858. This was built in a V shape which angled out from both shores and met in mid river.

A canal was built angling inland from the mill pond and running along the shore to carry water to various mill sites. Included smaller canals to carry water from the main canal (headraces) to the mills, and from the mills back to the river (tailraces). When the system was completed the Minneapolis manufacturing district consisted of 2.9 miles of tunnels and open canals. By 1869 Minneapolis was producing five times as much flour and twice as much lumber as the St. Anthony (east side) manufacturers.

Lower Dam Water Power Station
8th Ave. S.E. and Mississippi River
Minneapolis

The Lower Dam was built by the Pillsbury-Washburn Flour Mills Company, owners of the St.Anthony Falls Water Power Co. Construction of the Lower Dam took place from May 13, 1895 to January 1, 1898. It was 1009' long, from 15' to 20' high, with a retaining wall along the east bank 1115' long and 18' high.

The Water Power Station was also built by the Pillsbury-Washburn Flour Mills Company. The one-story tile and stone building measured 57' x 250'; the turbine chambers almost 40' x 250', sufficient space for ten 700 KW generating units to be directly connected to horizontal water wheels (turbines).

The machinery installed during 1897 consisted of the following.
Five General Electric Co. 700 KW, multi-polar, 3-phase, 3450 volt, 35 cycle, A.C. Alternators.
Two General Electric Co. 700 KW, multi-polar (8), 600 volt D.C. Generators.
To the generator shaft of each of these seven units was directly connected two pairs of 42" horizontal turbines (a total of four 42" wheels for each unit) manufactured by the Stillwell-Bierce and Smith-Vaile Company. These "Victor" turbines operated at 130 r.p.m. and were rated at 250 h.p. each, or 1,000 h.p. per generating unit. In the east end of the building were two D.S. Morgan Water Wheel Company 150 h.p. turbines directly connected to two 100 KW, multi-polar, continuous generators providing excitation current to all of the 3-phase Alternators in the station. Two headgates, each 8' wide by 9' high, admitted water to the turbine chambers.
The first power unit went into service November 12, 1897. Three additional General Electric Co. 700 KW, multi-polar, 3-phase, 3450 volt, 35 cycle, A.C. Alternator units were installed during 1898. This completed the full station complement of eight Alternator units and two Generator units. The A.C. Alternators generated 3450 volts A.C. for short distance transmission and for stepping up to 12,000 volts A.C. for long distance transmission. The two D.C. Generators provided 600 volt D.C. for operating nearby lines.

The original intention was to shut down the three existing steam stations (combined capacity 5,000 h.p.). Two were to be retained as standby plants: 3rd Ave. N. and 2nd St. N., Minneapolis; Hill St., St.Paul. The third plant would be dismantled: 31st St. and Nicollet Ave., Minneapolis. But this was not immediately done. Refer to the sections on the histories of these three plants for further explanation.

During 1903-1904 provision was made for temporarily installing Rotary Converters. Alterations were made to the leased building to accomodate a substation. The 1904 plans called for the location of four Rotary Converters here. One 1500 KW Rotary Converter was in use as of January 1904 and was still in operation March 1905. During 1905-1906 a large investment was made in reconstructing and improving the power distribution. This included the removal of the 1500 KW Rotary Converter (to one of the new substations, either 11th St., Minneapolis, or College Ave., St.Paul) and permanently installing four 600 KW Rotary Converters as Substation #13.

TCRT discontinued the lease during July 1950. The plant was taken out of service and all cables in the 8th Ave. S.E. tunnel to the Main Steam Station were removed. In October 1951 the real estate and plant were transferred to Northern States Power Co. N.S.P. Co. rebuilt the plant with ten outdoor type vertical 60-cycle A.C. generators. The first unit was placed in service 7-14-1952; the tenth and last unit 7-29-1952. The reconstructed plant developed a head of 25 ft. instead of 20 ft. in the original plant due to additional dredging at the plant site. On November 9, 1987, tghe main floor of the powerhouse and most of its roof collapsed because of a sinkhole underneath the limestone foundation. The plant was subsequently demolished and completely removed.

Substations
1897-1904

Three substations were placed in service during late 1897 when power was first furnished by the Lower Dam Water Power Station.

#1. Minneapolis, in the heart of the city, 1.7 miles from the LDWPS: probably at 3rd Ave. N. and 2nd St. N. Transmission was at 3450 volts A.C. and the equipment consisted of two 600 KW Rotary Converters.

#2. Minneapolis, 4.5 miles from the LDWPS: probably at 31st St. and Nicollet Ave. Transmission was at 3450 volts A.C. and the equipment consisted of one 600 KW Rotary Converter.

#3. St.Paul, 10 miles from the LDWPS in the Hill St. Steam Station. Transmission was at 12,000 volts A.C. and the equipment consisted of two 600 KW Rotary Converters. Paper-insulated underground cables were used in the distribution system.

Substation #4 was located on the northeast corner of Dale St. and Aurora Ave. in St.Paul. Lot 16 was purchased in April 1899. A building was erected and one 600 KW Rotary Converter installed, all during 1899.

Two additional 600 KW Rotary Converters were ordered from General Electric Co. in January 1900. They were not received until March 1901. One was installed at Substation #1 and one at Substation #4. This gave a total of eight 600 KW Rotary Converters.

The first power was generated by the new Main Steam Station, Minneapolis, in December 1903. The eight existing Rotary Converters were "remodeled" during late 1904 to early 1905 and all moved to new locations. The four in existing Minneapolis Substations went to the Lower Dam Water Power Station's Substation. The four in existing St.Paul Substations went to the new Substations on the Stillwater Division: three to Wildwood Substation one to Stillwater (Owen St.) Substation.

Cables were removed from the old Dale St. Substation #4, St.Paul, during September 1905. The property was not sold until August 1909.

1902 U.S. CENSUS DATA
Steam and Water Power Plants

Description	Quantity	Total H.P.	Voltage	Location
Steam Engines	3	600		(1)
Steam Engines	1	525		(1)
Steam Engines	5	6000		(1)
Boilers	20	4210		
D.C. Generators	36	8000	580	
D.C. Generators	2	2000	650	(2)
A.C. Dynamos	8	8000	3450	(2)
Water Wheels	2	280		(2)
Water Wheels	10	10000		(2)
Substation Equipment	8 Rotary Converters			(3)
Substation Equipment	2 Storage Batteries			(4)

(1) Probably three each at 3rd Ave. N., Hill St.; and one each at North St.Paul, Wildwood, Stillwater.

(2) Lower Dam Water Power Station.
(3) Three at 3rd Ave. N., one at 31st and Nicollet, two at Hill St., and two at Dale St.
(4) One at 3rd Ave. N., Minneapolis, and one at 10th and St.Peter, St.Paul.

Hennepin Island Water Power Station
Hennepin Island
Minneapolis

The St.Anthony Falls Water Power Company completed construction in May 1908 of this new hydro-electric plant. Equipment consisted of four turbo-electric, 35-cycle, A.C. Generators of 2250 KW capacity each for a total capacity of 9000 KW. There also were two exciter units of 150 KW D.C. each. This plant had no mill power available to it but utilized excess water not required elsewhere. The facility was leased to the Minneapolis General Electric Co. 10-1-1907 which sub-leased it 1-2-1908 to TCRT. The plant was electrically connected to the new Main Steam Station June 23, 1908.

This plant furnished the very last 35-cycle power for the street railway system, for operating the Snelling Shops until July 2, 1954 when it was closed down. TCRT had discontinued the lease in June 1954. By the end of 1954 N.S.P. Co. had installed three new 60-cycle machines of 2475 KW each. In 1957 it was reported that the complete installation would be made up of five units with a total capacity of 12,400 KW. As of December 1998 the plant was still in service with a capacity of 12.5 megawatts.

Lower Dam and Hennepin Island Water Power Stations
Description of Operations
March 1938

The generators had been tested and repaired and all the equipment made ready to take advantage of the first rise in the river which usually occurs about March 20th. There is a daily increase in the output of power from these stations while the ice leaves the river and by April 1st they usually run at full capacity, delivering about 50% of the power required to run the streetcars in Minneapolis-St.Paul. With normal rainfall this condition lasts until late June when the river again begins to recede and the water-power generators are gradually taken out of service. Lower Dam receives the full flow of the river and consequently has some output the year around. Hennepin Island located at the upper dam runs only when there is a surplus of water or when the water wheels that hold first right to the river flow are shut down.

Street Railway Review
Comments on Power Houses
from 2-15-1899 issue

Power House #1 3rd Ave. N.
Two 3450 volt AC transmission lines: triple conductor, paper insulated, lead covered cables, each equivalent to 3/0 B&S wires. Distance about 9000 ft. Steam equipment was in reserve. One 600 kw Rotary Converter was in service.

Power House #2 31st St.
One 3450 volt AC transmission line, cable equivalent to 4/0 B&S wires. Distance 4 1/2 miles.
Engines removed [Generators?]. Boilers remained. One 600 kw Rotary Converter was in service.

Power House #3 Hill St., St.Paul
One 12,000 volt AC transmission line, triple conductor cable of three 0 wires. Distance about 10 miles. Two Rotary Converters in service. Steam equipment still carried part of the load.

AC transmission cables are all laid underground in cement-lined sheet-iron pipe, 4 1/2" outside diameter, 3" inside diameter. There is about 100,000 feet of this conduit laid.

LDWPS
In full operation by 2-19-1898. Available head 16 to 21 ft.; average 19 ft.
40,000 lb. P&H traveling overhead crane. Six G.E. Transformers for stepping up voltage for transmission to St.Paul.

St. Paul & Suburban Ry. North St. Paul Power House
2 Babcock & Wilcox Boilers
2 100 h.p. Ideal Engines
3 Thompson-Houston 90 kw multi-polar Generators

Sanborn Insurance Maps

Selby Ave. Powerhouse 1903
Two Engines @ 500 h.p. each, two Generators, two Boilers.
Also 4 old Boilers not used (from cable powerhouse).

North St.Paul Powerhouse 1903
Two Engines @ 100 h.p. each, two Dynamos, two Boilers.
"Runs Saturdays and Sundays; closed rest of the time."
Carhouse: "storage of old cars".
Station building on opposite side of the main track: "Not Used"

Wildwood Powerhouse 1903
One Engine @ 750 h.p., two Dynamos, three Boilers (two plus one).

Stillwater Powerhouse May 1904
One Engine @ 200 h.p., two Dynamos, five Boilers (four plus one).

A MODERN TRIUMPH
Minneapolis Tribune (1867-1908); Dec 26, 1897;
ProQuest Historical Newspapers Minneapolis Tribune (1867-1922)
pg. 11

A MODERN TRIUMPH

Old Mississippi's Waters to Move the Street Cars of the Twin Cities.

CHANGE WILL BE MADE JANUARY 1.

Completion of an Undertaking That Involved $178,000 in Wages and a Total Expense of $1,028,000.

The ever-flowing waters of faithful old Mississippi have been harnessed, and in their onward course to the sea will pause a moment to set in motion the wheels of commerce in the city of Minneapolis. The latent energy of the rapidly moving current will generate the mighty force, electricity, which will send trolley cars, with their loads of human freight, whirling through the streets of two great cities, and eventually turn the wheels that grind the golden grain, and buzz the saws which cut the massive logs from the forests of the North.

It was splendid foresight that prompted J. E. Stillwell, of the Westinghouse company, of Pittsburg, to call the attention of Thomas Lowry to the wonderful advantages to be attained by the utilization of the water power, either at the falls of St. Croix or below St. Anthony falls, in Minneapolis, for street railway purposes. Mr. Lowry, with keenness and judgment, saw the value of the suggestion, and began at once to make a thorough investigation. The advantages of the Minneapolis power were apparent upon first inspection, and a corps of engineers of the Twin City Rapid Transit Company was soon busily engaged in making plans and estimates, ascertaining the cost of the dam, the cost of machinery, what the probable power would be, and how much the cost of the production of electricity could be reduced. Many plans and suggestions had to be discarded as impracticable or too expensive. In 1894, however, the final estimates were prepared, and it was then that Charles A. Pillsbury became interested in the project. To his indomitable perseverance and shrewd business ability is due the successful accomplishment of the stupendous undertaking. The very enthusiasm which he manifested in the proposition made it possible for him to secure money from the English capitalists with whom he is connected in the Pillsbury-Washburn Flouring Mills company. A company was organized with Mr. Pillsbury at its head. Work was begun in May, 1895, and at the close of the first year over one-half of the work was done. The new water power company, realizing that the Twin City Rapid Transit Company was by far the largest user of steam power in the city, entered into negotiations with the latter company for the sale of the power which it was expected would be generated. In November, 1896, a deal was closed by which the railway company agreed to take all of the power developed by the Mississippi at the dam for a period of [illegible] years. Just what the basis of the agreement was, the public will probably never know. By this contract the railway company may sell all of the electrical power generated which it does not need for its own use.

FINE PIECE OF WORK.

The new power dam is a magnificent piece of civil engineering. It begins at the west end bank of the river, at a point [illegible] feet below the Tenth avenue bridge, and runs parallel with the bridge for a distance of about [illegible] feet. It then turns at an obtuse angle and runs down stream, nearly parallel with the east bank of the river, for a distance of [illegible] feet, making a total length of 1,065 feet. The latter portion of the dam forms one side of the head race, which is [illegible] feet wide and leads to the power house. The water in this head race will stand [illegible] feet deep.

In building the dam the excavation was extended down to sand rock, upon which was spread a bed of concrete about 35 feet wide, and three feet deep, extending all the way across the masonry the dam was laid. Under the crest line of the dam a dyke extends 12 feet in depth and six feet wide, underlaying the concrete bed, to prevent the undermining of the dam. This dyke is built of rubble rock, laid in the best quality of cement, and with the greatest care.

The up-stream face of the dam is perpendicular, with a coping of cut granite; the down stream face having a long slope that serves as an apron to ease the momentum of the water. This apron is so shaped that the toe of it discharges the water into the river in a horizontal direction, thus preventing the undertow that is usually so fatal to a dam. As this long graceful apron is so constructed as to let the discharged water into the river at a line almost parallel with the water bed, a person watching the overflow will hardly realize its energy from the silent, easy manner of its gliding on its down-stream way.

DAM 18 FEET HIGH.

The dam is about 18 feet high above the concrete sub-base. Taking this height and its base of 35 feet into consideration, with its length of 1,065 feet, some idea can be had of the stupendous task of its construction. But this is not all. There is the dyke, or sub-foundation, six feet wide, 12 feet deep and 1,065 feet long to be added, to the other figures. Between this and the dam proper comes the layer of concrete three feet thick and 35 feet wide, so that the total height of the dam, from away down below the river bed up to the crest, is 33 feet, of which 12 feet is sub-base, three feet the concrete and 18 feet the superstructure.

In the dam are built three huge submerged waste gates, or "bear traps," each 50 feet in length. Two of these are located near the power house, and one at the west end of the dam. They will be used to control the height of the water in the pond. They work almost automatically by hydrostatic pressure, the labor of opening and closing them being performed by one man. At the west end there is also a sluice way for saw logs, in which the descent is very gradual.

THE POWER HOUSE.

The power house is 250 feet long and 54 feet wide, exclusive of the wheel chambers, which stand out 30 feet farther. The power house is strongly built of brick and tiling upon a solid granite foundation, and is strongly braced with iron trusses. The power house consists of 10 wheel chambers or units, each of which is equipped with two pairs of horizontal turbine wheels of 500 horse power capacity each, so that each chamber or unit is of 1,000 horse power capacity, or a total of 10,000 horse power. These turbines will be operated under a head of water varying from 18 to 20 feet, according to the stage of the water in the river. The shaft of each turbine, prolonged, is run into the power house, where it is connected directly with a dynamo or generator of 1,000 electrical horse power. There are 10 of these dynamos, each attached to the shaft of a turbine wheel, which avoids the necessity of belts, counter shafts, gearing, etc., etc.

Specifications for all the apparatus required for the power house, and the conversion of the power to a current of the proper pressure for street railway trolleys were issued, and estimates and proposals for the apparatus were received during the latter part of the year 1896. William de la Barre, engineer, agent and treasurer of the water power company, under whose supervision the dam was constructed, accompanied by C. G. Goodrich, vice-president of the street railway company, and E. P. Burch, electrical engineer of the railway company, spent considerable time investigating the plants and factories east of the Mississippi, which are engaged in heavy power transmission. The principal electrical factories in Chicago, Pittsburg, Niagara, Buffalo, Schenectady, Pittsfield, Mass., and New York were visited, and a part of the engineers went through the underground cable manufactories at Chicago, Pittsburg, New York and Schenectady. For many months the experts figured on plans and specifications, and for weeks considered bids submitted by the leading electrical companies in the United States. The bidders for the equipment of the plant were the General Electric company, of Schenectady, N. Y.; the Westinghouse Electrical Manufacturing company, of Pittsburg; the Stanley Electric company, of Pittsfield, Mass., and the Wagner Electric company, of St. Louis.

THE CONTRACT LET.

Jan. 1, 1897, the contract for the great plant was let to the General Electric company, and that concern went immediately to work manufacturing the immense dynamos, and the vast amount of intricate electrical apparatus required. The work progressed rapidly during all the months of the present year, and the plant will be in complete condition, with all tests made, by Jan. 1, 1898, when it will be turned over to the Twin City Rapid Transit company. It is the finest water power electrical plant in the world with the exception of that at the falls of Niagara.

The railway company has found that it requires 7,000 horse power to operate its trolley cars in the cities of Minneapolis and St. Paul, with a total of over 125 miles of line, including the interurban line. Provisions have been made, therefore, for the generation of only that amount of power. The present equipment consists of two generators of direct current, of 600 volts capacity, running 130 revolutions to the minute, and five alternating current generators, of 3,500 volts, running at the same speed per minute. For the purpose of exciting the generators of the direct current, two small dynamos are run by two sets of water wheels of 130 horse power capacity, under a platform at the east end of the power house. The large generators all stand in a line on the cement floor of the power house, and although they weigh nearly [illegible] tons each, with a main shaft of 12 inches in diameter, they run as smoothly and glide as noiselessly as the works of a watch. Their speed depends upon the load upon them, and the speed of the water wheel which turns them, and in order to regulate the revolutions of the monster dynamos, each unit or turbine is connected with a very pretty yet complicated little machine called the Lombard hydraulic governor, a system of oil and air, attached with a system of gearings direct with the gate, and as the speed of the dynamo increases or decreases, the governor will open or close the gates, admitting more or less water to the wheel, as the case may be, and keeping the speed of the dynamo at the same number of revolutions per minute at all times. The governor is controlled by a belt on a four-ball governor head and the centrifugal force of the balls act upon a valve which controls a piston which opens or closes the gate. There is a gauge on the machine which indicates the amount of water power passing through the gate and over the wheel. By the use of these governors the speed of the dynamos which generate such a vast power can be regulated as closely as if run by steam engines.

It need be said that the street cars as they are seen running rapidly up and down the streets of the city, are propelled by the direct current, and that, therefore, the alternating current created by five of the large dynamos must pass through the process of conversion into the direct current before being transmitted onto the trolly wires. For this purpose there are two sub-stations, one on Third avenue north, Minneapolis, and one in St. Paul, which are equipped with what are called "converters," big machines that look very much like the dynamos. There are 15 of these converters, to which the alternating current is conveyed through the heavy copper wires in the under-ground conduits, at the pressure of 3,500 volts, and is reduced into the direct current of 600 volts, which is the pressure at which it is sent out on the trolly wires. The two dynamos at the power house which generate the direct current will be used to operate the Interurban line, the various connecting lines in both cities being operated directly by the currents from the sub-stations. The economy of this plan is apparent.

THREE MEN EMPLOYED.

Strange as it may seem, but three men will be employed at the power house where this immense power is created; a night and day operator and a wiper. Running the entire length of the north side of the power house is a wide gallery, upon which stands a special fire-proof switch board, of blue Vermont marble, 74 feet in length and 90 inches high. It is a marvel of electrical wiring, and contains apparatus in the shape of chronometers, dials, indicators, recorders and switches of the finest manufacture, and most intricate construction, and sufficient to puzzle any but the most expert electricians. By the use of a few levers, the operator has under his control the entire system. He can open and close the gates that admit the water to the turbine wheels, regulate the speed of the dynamos, shut the current off on any of them, and is in touch with both sub-stations by special telephone connection. To the operators in the sub-stations is left the distribution of the current upon the different street car lines. The gallery is also furnished with neat office equipment in the way of tables, etc., etc. Visitors to the power house will not be admitted to the gallery for the reason that the operator is required to exercise constant vigilance over the system which he controls, and for the further reason that there are exposed cables and wires, which, if touched, would cause instant death.

The cost of this immense undertaking and the complete equipment is an interesting item; up to the present time there have been expended as wages, aside from that paid out by contractors, $178,000. The building of the dam has cost $550,000, while the electrical apparatus and other machinery has cost over $300,000, a total of $1,028,000.

As rapidly as demand is made for additional power other dynamos will be put in, and sufficient power can be generated to operate, in addition to the street railway systems, mills and factories of unlimited capacity, and the current can be transmitted by means of cables for long distances without material loss.

The plan is therefore of inestimable value to the commercial interests of the city, and will play a most important part in the future greatest and supremacy of Minneapolis.

MAIN STEAM STATION
6th Ave. S.E. and the Mississippi River
Minneapolis

It had been learned that the Lower Dam Water Power Station could not be relied upon for an uninterrupted supply of power, and that a large steam station with adequate reserve capacity was necessary. This led to the design and construction of a new comprehensive generating plant on land located adjacent to the Lower Dam Water Power Station. Design consultants were Sargent & Lundy, Chicago, and F. S. Pearson. Original plans called for the use of 3,450 volt 3-phase Alternating Current as the transmission voltage so that the plant could operate in parallel with the Lower Dam Water Power Station. The basic power unit was to consist of one 3,500 KW, 3-phase, General Electric Co. generator direct-connected to one Allis-Chalmers vertical compound condensing Reynolds-Corliss engine (46" x 94" cylinder, 60" stroke, 75 r.p.m.). The building was designed to contain six units of this size plus allowing for indefinite expansion.

Construction started during 1902 on the building, 156' x 255' x 86' high, consisting of a brick superstructure on a heavy limestone foundation.

To provide additional capacity pending completion of the Main Steam Station, temporary extensions were made at (1) Power Station #1 (Main Central Powerhouse), Minneapolis, and (2) Selby Ave. Powerhouse, St.Paul. Six Babcock & Wilcox 556 h.p. Boilers equipped with coils for superheating steam were ordered. Four went to Power Station #1 and two to Selby Ave.

Three Engine-Generator units, #1, #2 and #3, were originally installed. Each consisted of one Allis-Chalmers vertical cross-compound (46" x 94" x 60"; 75 r.p.m.; 5,000 h.p.) condensing Engine, and one General Electric Co. 3,500 KW Generator. Eighteen Babcock & Wilcox Boilers, rated at 556 h.p. each and equipped with Roney stokers, were installed. Six, #1 to #6, were from the 1902 temporary installations, and twelve, #9 thru #20, were new. Expansion allowed for a total of five engine-generator units and 24 boiler units. The current generated was 2,300 volts, 35 cycle, A.C., stepped up to 13,200 volts A.C. for distribution to the substations. The boilers burned Pocahontas coal shipped in by railroad. The railroad connection, together with several spur tracks serving the coal bins and ash hoppers, was built by TCRT for 600 volt D.C. third-rail operation. Coal was dumped on a conveyor belt and delivered to crushers located in the tunnel under the coal bins, and under the main receiving hopper in the boiler room basement. From there an elevator raised the coal to a bin in the upper portion of the boiler room. As needed coal passed down chutes into automatic stokers which fed the boilers. The coal conveyors and crushers had a capacity of 75 tons per hour. Storage bins outside held 3,000 tons. Combination coal and ash handling machinery was also used. The distribution system consisted of underground conduits (heavy three-conductor lead-covered cables), overhead transmission lines, and overhead feeder cables. The first power was produced during December 1903.

During 1904 a number of important changes were made in the power distribution system. As related in previous sections, the various existing steam stations and four existing substations were gradually taken out of service. On the Stillwater Division, the three steam powerhouses were taken out of service. Four new substations were constructed.

A 11th St. and Hennepin Ave., Minneapolis, begun 1903.
B College Ave. and Wabasha St., St.Paul, begun 1903.
C Wildwood (an addition to the existing powerhouse building), begun November 1903.
D Owen St., Stillwater, begun September 1904.

The relocation of the rotary converters has previously been described.

A cross-country high-tension transmission line was built during 1904 from the Main Steam Station to Wildwood and Stillwater, together with the Como, Wildwood and Stillwater Terminal Houses. Underground cables ran from the steam station to the Como Terminal House located at 21st Ave.

S.E. and Talmadge Ave. S.E. From there the line was carried on wood poles. The route location:

on	from	to
Broadway St.	Como Terminal House	Minneapolis city limits
County Road B	Minneapolis city limits	Arcade St.
Arcade St.	County Road B	County Road C
County Road C (south side)	Arcade St.	White Bear Ave.
White Bear Ave. (west side)	County Road C	County Road D
County Road D	White Bear Ave.	Pole 845 on the r/w at Long Lake
R/W overhead poles	Long Lake	Wildwood Terminal House
R/W overhead poles	Wildwood Terminal House	Stillwater Terminal House.

The Wildwood Terminal House was located on the right-of-way just north of the powerhouse-substation building. The Stillwater Terminal House was located at the rear of the Owen St. substation building.

The TCRT 1904 Annual Report, dated January 20, 1905, stated that "Completion of our steam plant and substations was delayed much longer than we anticipated and were not finished until the month of December so that we received no benefit from them for the year 1904.".

Engine-Generator #4, identical to #1-#2-#3, was ordered during 1904 and installed in April 1906 to meet the power needs of the Lake Minnetonka Division. Six Boilers, #23 to #28, rated at 556 h.p. each, were installed during 1905. This gave the steam station a total generating capacity of 14,000 KW.

During February and July 1907 the first two Turbo-Generator units, #5 and #6, were installed. Each consisted of one Curtis Steam Turbine and one General Electric Co. 5,000 KW Generator.

Beginning in 1909 chain grate stokers were installed replacing the original Roney stokers.

A decision was made to replace the vertical compound engines and engine-type generators with more modern turbo-generator units. Turbo-Generator units #1-#2-#3 replaced Engine-Generator units #1-#2-#3 during 1911 to 1913.

#1 Curtis Steam Turbine and General Electric 14,000 KW Generator: February 1911.
#2 Curtis Steam Turbine and General Electric 15,000 KW Generator: 1912.
#3 Curtis Steam Turbine and General Electric 15,000 KW Generator: 1913.

This left only one Engine-Generator unit, #4. The total generating capacity of the station was now 57,500 KW.

Four Babcock & Wilcox Boilers rated at 514 h.p. each were installed, two in 1910 and two in 1912. These were numbered #7-#8 and #21-#22. This gave a total of 28 low-pressure Boilers, #1-#28: 200 p.s.i. steam pressure at 500 degrees F.

Two Custodis radial-brick smokestacks 162' high were originally constructed. These were replaced by four brick-lined steel smokestacks, 14' diameter x 265' high,--two in November 1910 and two in August 1912.

The largest and most efficient steam turbine-generator unit to date was installed, completed during November 1917. This was Turbo-Generator unit #4 which replaced old Engine-Generator unit #4. This new unit consisted of one Curtis Steam Turbine and one General Electric 20,000 KW Generator. The total generating capacity of the station was now 74,000 KW.

No further additions or major improvements were made to the steam station throughout the 1920's.

During 1930-1931 Turbo-Generator unit #4 installed in 1917 was rebuilt and modernized. Two new Babcock & Wilcox Boilers, A and B, (460 p.s.i., 735 degrees F) were purchased at a cost of $125,000 for Turbo-Generator #4 and installed during 1931-1932. These replaced eight old low-pressure Boilers, #11-#18, which were retired. The new Boilers had Westinghouse fourteen-retort underfeed stokers.

During 1934 one of the two vertical 200 p.s.i. Steam Turbines, #5 or #6, was rehabilitated. Only two units, #4 and this one, were needed to meet the 43,000 KW peaks. At this time it was reported that 1.47 lbs. of coal per KWH were consumed.

During 1936 it was necessary to rebuild the steam turbine of one of the 15,000 KW units, #2 or #3, and to completely overhaul the two smaller 5,000 KW units, #5 and #6.

During 1937 the most modern type oil switches and reactors were installed throughout the station.

Turbo-Generator unit #1 (14,000 KW) which had been out of service for several years was rebuilt and placed back in operation during 1938. (This was classified as a reserve unit in 1944.)

An article in the TCL Credit Union's BUS AND TROLLEY NEWS November 1937 issue "From the Steam Plant" describes the operation of Boilers A and B. This is quoted verbatim.

> The two big boilers at the Steam Plant are now ready for another winter season of heavy service. These two boilers were installed and put in service in 1932 and since then have percolated very satisfactorily and economically as compared to the eight old chain grate boilers which they replaced at that time. The station coal rate, that is pounds of coal per kilowatt, has reduced from over 3.0 with the old chain grate boilers to less than 1.5 with these new boilers and more efficient operation of the plant.
>
> To give the readers---a better idea of the large size and capacity of these Stirling Water Tube Boilers we will mention a few figures. Each of the boilers has a 14-retort Westinghouse stoker or furnace, approximately 25' wide and 18' in length, and which burns over 8 tons of coal per hour during maximum operation. The heating surface of each boiler is 16,438 sq. ft. and other heating surfaces are: superheater 5,660 sq. ft., economizer 3,686 sq. ft., and air pre-heater 14,176 sq. ft. Each of the two boilers, which are called A and B, is rated at 175,000 lbs. of steam per hour as maximum output, but have in emergencies delivered as much as 225,000 lbs. of steam per hour. They operate under a steam pressure of 425 lbs. per sq. in. and deliver all the steam required by No. 4 Turbine, which was rebuilt for this pressure at the same time the boilers were installed. Surplus steam from the boilers is passed through a reducing valve and is used by the 200 p.s.i. turbines.
>
> Each boiler is supplied with a 100 h.p. fan which forces the air at room temperature through a pre-heater, where it is heated to a temperature of 300 degrees F. before it enters the furnace. There are 1,050 tubes and four large drums in each boiler; each tube is 3½ inches in diameter and where these tubes and drums are located the maximum temperature may reach as high as 1,000 degrees F.
>
> The waste gases are drawn from each boiler with a 200 h.p. induced draft fan and a large steel smoke stack which towers 263 ft. above the boiler room floor. These waste gases, which have a temperature of 750 degrees F. when leaving the boiler, perform two important functions. First they are passed around the tubes in the economizer, which is part of the feedwater heating apparatus, and second they pass through the air pre-heater. By heating the feedwater in the economizer the temperature of the waste gases at this point is reduced to 550 degrees F., and after having heated the incoming air in the pre-heater it is further reduced to 380 degrees F., at which temperature they are allowed to escape through the stack.

During 1941 new Boiler C was installed at a cost of $251,259. It was manufactured by Combustion Engineering Co.; 475 p.s.i., 735 degrees F. This was the first boiler equipped to burn either natural gas or pulverized coal. Previously the station operated exclusively on coal. This new Boiler replaced five old low-pressure Boilers, #9-#10 and #19-#21, which were retired.

During 1943 Boilers #1, A and B were equipped with natural gas burners so they could burn either natural gas or coal.

In 1944 one new horizontal 15,000 KW Turbo-Generator unit, Curtis Steam Turbine-General Electric Generator, (estimated cost $657,000) was ordered for installation in 1945 to replace the two old 5,000 KW Turbo-Generator units #5 and #6. These two old units were obsolete and unreliable and were used for emergency operation only. Installation of this new unit, #5, was completed in 1946. Total plant generating capacity then was 79,000 KW.

The last major improvement was the installation of new Boiler D during 1949-1950. This was a Babcock & Wilcox natural gas/coal fired boiler, 440 p.s.i., 850 degrees F., which cost $471,686. It replaced ten old low-pressure Boilers, #2-#8 and #22-#24, which were retired.

During 1953 Turbo-Generator units #2 and #3 were scrapped. The five remaining low-pressure Boilers, #1 and #25-#28, were also scrapped.

During the last year of operation, the remaining equipment consisted of Turbo-Generator units #1, #4 and #5, with Boilers A, B, C and D.

The real estate, building and above machinery were sold to Northern States Power Co. after the end of streetcar operation in July 1954 for conversion to a peak load facility. Two existing generating units (probably #4 and #5) were rebuilt for 60 cycle operation. The first unit was placed in service November 13, 1954. The remaining coal-fired boilers were converted from coal to natural gas. After rebuilding the total plant generating capacity was 60,000 KW. N.S.P. Co. operated the plant until 1974. The facility was sold to the University of Minnesota in 1977.

MAIN STEAM STATION RAILROAD
and
RAIL EQUIPMENT

The trackage was powered by 650 volts D.C. third rail to facilitate unloading of railroad coal cars by crane cars fitted with clamshell buckets. Track details are shown on the two track maps appended and track mileage itemized in the chapter on Carhouses and Shops. The Locomotive is accounted for in the chapter on Equipment.

The original crane was a Brown Hoisting Machinery Co. Model 315 with a 54 cu. ft. clamshell bucket. Equipment consisted of one G.E. C.O. 2001 80 h.p. electric motor adn one R-27 controller. This crane was retired in 1948.

Gondola Trailer number 6 was purchased in 1910 and retired in 1947.

An American Hoist & Derrick Co., St.Paul, Type 258 25-ton locomotive crane, serial number 1243, minus the steam boiler and engine, was purchased in September 1924. The clamshell bucket capacity was 2 cu. yds. TCRT furnished and installed the electrical equipment which consisted of one G.E. C.O. 1812 motor and one G.E. R164A controller. This crane was purchased by Northern States Power Co. with the Main Steam Station in July 1954. It was donated to the Minnesota Transportation Museum Inc. in 1968. As it was in deteriorated condition and beyond economical useful restoration it was dismantled for parts in 1970.

An air-operated side-dump car was purchased second-hand in 1942 from a steam railroad. Received on October 6, 1942 it was used for transferring coal from the new #7 coal bin to hoppers in the building. The car was purchased by Northern States Power Co. with the Main Steam Station in July 1954. It was donated to the Minnesota Transportation Museum Inc. in 1968. As it was in deteriorated condition and beyond economical useful restoration it was dismantled for parts in 1970.

A new American Hoist & Derrick Co., St.Paul, Model 825-E, 25-ton, 75 h.p., electric locomotive-crane was acquired during the winter of 1946-1947. This crane was acquired by Northern States Power Co. with the Main Steam Station in July 1954. It was disposed of by N.S.P. Co. in 1969.

POWER STATION AND SUBSTATION NUMBERS

Each facility was assigned a number for cable identification purposes.

1	Main Steam Station
2	Lower Dam Water Power Station
3	Hennepin Island Water Power Station

11	11th St. Substation	22	Harriet Terminal House (built 1905)
12	11th St. Sub Bus	23	Hopkins Substation
13	Lower Dam Substation	24	Fair Oaks Terminal Pole (*)
14	Lake St. Substation	25	Excelsior Substation
15	College Ave. Substation	26	Linwood Terminal Pole (*)
16	Snelling Ave. Substation	27	Big Island Substation (*)
17	Snelling Transfer Bus	28	32nd Ave. N. (Lowry) Substation
18	Como Terminal House	29	Hope St. Substation
19	Wildwood Terminal House	30	Minnehaha Substation
20	Wildwood Substation	31	University Substation
21	Stillwater Substation	32	Girard Substation
		33	Concord Substation

(*) The A.C. transmission line to Big Island Park ran two miles overhead from Fair Oaks to Linwood, then ½ mile by submarine cable to the substation on the island.

Electrical Distribution System
1944

Underground cable tunnels	10,500	l.f.
cable duct under street surface	66.7	miles
4/0 13.2 KV lead-covered A.C. transmission cables	99	miles
1,000,000 mil 600V D.C. lead-covered cables	95	miles
500,000 mil overhead feeder cables	338	miles
circuits from substations to overhead system	137	each
outdoor pole-type switches connecting overhead to underground	376	each
automatic sectionalizing switches	52	each
3/0 trolley wire	445	miles

A.C. TRANSMISSION SYSTEM

1-1-1925

CABLE A

2-A-1	Lower Dam to Main Steam Station	1,476 LF	
3-A-1	Hennepin Island to Main Steam Station	1,457 LF	(submarine)
1-A-11	Main Steam Station to 11th St. Substation	10,510 LF	(submarine)
1-A-12	Main Steam Station to 11th St. Substation Bus	11,410 LF	
12-A-22	11th St. Substation Bus to Harriet Terminal House		
	underground to Manhole 574	12,539 LF	
	overhead from MH 574 to the terminal house	10,930 LF	
12-A-32	11th St. Substation Bus to Girard Substation	12,604 LF	
1-A-14	Main Steam Station to Lake St. Substation	13,988 LF	(submarine)
14-A-30	Lake St. Substation to Minnehaha Substation	8,397 LF	
14-A-32	Lake St. Substation to Girard Substation	9,137 LF	
1-A-16	Main Steam Station to Snelling Substation	13,597 LF	+
		12,089 LF	
1-A-17	Main Steam Station to Snelling Substation Transfer Bus	13,971 LF	+
		12,059 LF	
17-A-15	Snelling Substation Transfer Bus to College Ave. Substation	17,569 LF	
15-A-29	College Ave. Substation to Hope St. Substation	10,526 LF	
15-A-33	College Ave. Substation to Concord Substation	8,580 LF	
1-A-18	Main Steam Station to Como Terminal House	10,404 LF	
32-A-22	Girard Substation to Harriet Terminal House		
	underground to Manhole 574	1,289 LF	
	overhead from MH 547 to the terminal house	11,025 LF	
1-A-28	Main Steam Station to Lowry Substation	19,213 LF	
1-A-30	Main Steam Station to Minnehaha Substation	15,906 LF	
1-A-31	Main Steam Station to University Substation	3,724 LF	
Total		242,400 LF	

CABLE B

2-B-1	Lower Dam to Main Steam Station	1,485 LF	
3-B-1	Hennepin Island to Main Steam Station	1,455 LF	(submarine)
1-B-11	Main Steam Station to 11th St. Substation	11,380 LF	(submarine)
1-B-14	Main Steam Station to Lake St. Substation	13,977 LF	(submarine)
1-B-16	Main Steam Station to Snelling Substation	13,508 LF	+
		12,088 LF	
1-B-17	Main Steam Station to Snelling Substation Transfer Bus	13,988 LF	+
		12,072 LF	
17-B-15	Snelling Substation Transfer Bus to College Ave. Substation	18,601 LF	
1-B-18	Main Steam Station to Como Terminal House	10,444 LF	
Total		108,998 LF	

CABLE C

2-C-1	Lower Dam to Main Steam Station	857 LF	
3-C-1	Hennepin Island to Main Steam Station	1,465 LF	(submarine)
1-C-11	Main Steam Station to 11th St. Substation	11,363 LF	(submarine)
1-C-17	Main Steam Station to Snelling Substation Transfer Bus	13,991 LF +	
		12,064 LF	
17-C-15	Snelling Substation Transfer Bus to College Ave. Substation	17,550 LF	
17-C-15	Snelling Substation Transfer Bus to College Ave. Substation	10,120 LF	
Total		67,410 LF	

CABLE D

2-D-1	Lower Dam to Main Steam Station	854 LF	
1-D-11	Main Steam Station to 11th St. Substation	10,585 LF	(submarine)
1-D-17	Main Steam Station to Snelling Substation Transfer Bus	13,450 LF +	
		15,552 LF	
17-D-15	Snelling Substation Transfer Bus to College Ave. Substation	19,850 LF	
Total		60,291 LF	

CABLE E

1-E-15	Main Steam Station to College Ave. Substation	13,880 LF +	
		32,488 LF	
Total		46,368 LF	

NO NUMBER

In St. Paul	553 LF	
Grand Total	526,020 LF	99.63 miles

OVERHEAD A.C. TRANSMISSION LINES

LAKE MINNETONKA DIVISION

Harriet Terminal House to Excelsior Substation		
1/0 Bare Copper (three wire system)	401,004 LF	25.32 miles

STILLWATER DIVISION

Como Terminal House to Owen St. Substation		
1/0 Bare Copper (three wire system)	413,724 LF	
#3 Bare Copper (three wire system)	152,560 LF	
	566,284 LF	35.75 miles

The Como Terminal House was located at 21st Ave. S.E. and Talmadge St.
The Minneapolis city limit was at 33rd Ave. S. E. and Talmadge St.

SUBSTATIONS

The typical substation building was approximately 50 ft. square with monolithic concrete foundation, cement brick walls, and a clear height in the machine room of 23' 6". The typical complement of equipment consisted of:

- two 1500 KW, six phase, rotary converters;
  - (Three types: General Electric Co. H.C. 16-1500-260 Form M, N, or K.)
- six 550 KW air blast transformers;
- five remote control oil switches;
- two air blast reactance coils;
- motor driven fans of 20,000 c.f.m. capacity;
- switchboard with machine panels, line panels and D.C. panels for ten outgoing feeders; and storage batteries for use as regulators during extreme load conditions.

Substation Rotary Converter History

This information is presented in the following format. Substation number, substation title, substation location, years of operation, converter unit number, capacity each, installation date, and explanatory notes, if any.

#11 11th St. 11th St. and Hennepin Ave., Minneapolis 1904-1954

Space was provided for six rotary converter units.

1-2-3	1500 KW	1904
4	1500 KW	1905
5	1500 KW	1912

One 100 KW motor-generator set was located here as of 12-31-1907. The booster set moved here in July 1904 from the Main Central Powerhouse (3rd Ave. N.) was moved to the Wildwood Substation in 1915. Unit 2 from the Concord Substation was moved here in 1947. Machinery only sold 1954 to Mid-Continent Development & Construction Company.

#13 Lower Dam Lower Dam Water Power Station, Minneapolis 1904-1949

1-2-3	600 KW	1905
4	600 KW	1906

There were six transformers (three each) for two transmission lines to the Main Steam Station. One 200 KW booster set was purchased in June 1906. Unit 4 was transferred to the Wildwood Substation March 1914. Ownership of units 1-2-3 was transferred to the St. Anthony Falls Water Power Co. prior to the 1-1-1916 Valuation. One booster set consisting of one G.E. 400 h.p. (440 volt) motor driving two 135 KW generators (including three transformers) was moved intact to the Minnehaha Substation April-June 1916. All cables were removed from the substation during 1949-1950.

#14 Lake St. Lake St. and Chicago Ave. S., Minneapolis 1906-1954

1	1500 KW	1906
2	1500 KW	1907

Building size was 50' x 55'. A 25' x 43' addition was constructed during 1942-1943 to house two 600 KW rotary converters from storage at the Hopkins Substation, originally installed 1905-1906 at the Excelsior Substation. Sold complete 1954 to Mid-Continent Development & Construction Co.

#15 College Ave. College Ave. and Wabasha St., St.Paul 1903-1953

Space was provided for six rotary converter units.

1	1500 KW	1903
2	1500 KW	1904
3-4	1500 KW	1907

5	1500 KW	1912
6	1500 KW	By December 1913
one	3000 KW	1916

Units 5 and 6 were moved to the Concord Substation in 1919 and 1917 respectively.

#16 Snelling Ave. Snelling Ave. and University Ave., St.Paul 1906-1953

1-2	1500 KW	1906
1-2	3000 KW	1913

Original units 1-2 were replaced by new units 1-2; the original units were moved to the new Girard Substation, Minneapolis. Two 300 KW motor-generator sets were purchased, one in 1909 and the other in 191? to supply power to the Snelling Shops. Machinery only sold 1953 to the Mid-Continent Development & Construction Co.

#18 Como Terminal House 21st Ave. S.E. and Talmadge Ave. S.E., Minneapolis 1904-1938

Contained the switchboard (underground to overhead) for the high-tension A.C. transmission line from the Main Steam Station to the Wildwood Substation.

#19 Wildwood Terminal House On the Stillwater R/W near Wildwood Substation 1904-1938

Building size 13' x 20'. Contained the switchboard (overhead to underground) for the high tension A.C. transmission line from the Main Steam Station.

#20 Wildwood 3.167 acres at Wildwood 1904-1938

Building size: 75' x 130' or 79' x 131'. This was originally a steam powerhouse; construction of an addition to the building for the substation began November 1903. This substation also furnished the power for Wildwood Park.

1	600 KW	1904
2	600 KW	1906
3	600 KW	1914

Construction Journal entries provided the following information.

November 1906: moved and installed three 600 KW rotary converters from St.Paul.

May 1909: moved one 600 KW rotary converter to the Stillwater Substation.

December 1913: expended $13,654 on the building and $13,754 on electrical equipment; no details given.

March 1914: moved one 600 KW rotary converter here from the Lower Dam Substation.

February 1915: moved one booster set here from the 11th St. Substation.

1933: moved the booster set to the Hope St. Substation. The booster cable was removed between Henry St. (North St.Paul) and Wildwood and re-installed between Duluth Ave. and Henry St. Salvaged overhead feeder cable from the Deephaven line was installed between Wildwood and Mahtomedi.

1938: after closing of Wildwood Park, the A.C. transmission line from the Main Steam Station to Wildwood was dismantled. The rotary converters were removed from the substation building.

#21 Stillwater Owen St. and Laurel St., Stillwater 1904-1932

Building size: 32' x 50'; construction began September 1904. A terminal house at the rear of the building contained the switchboard for the high-tension A.C. transmission line from the Main Steam Station that passed through the Wildwood Terminal House.

1	600 KW	1904
2	600 KW	1909

An extension to the building was constructed May-June 1909 to accommodate the 600 KW rotary converter moved here from the Wildwood Substation.

#22 Harriet Terminal House Upton Ave. S. on the Harriet R/W, Minneapolis Built 1905
Contained the switchboard for the high-tension A.C. transmission line from the Main Steam Station to Excelsior: underground to overhead. The transmission line ran underground from the Main Steam Station through the 11th St. Substation to the Terminal House. From there the transmission line was carried on the overhead poles to the Hopkins and Excelsior Substations.

#23 Hopkins Washington Ave. and 3rd St., Hopkins 1905-1943
Building size: 42' x 74' or 40' x 72'.
1-2 600 KW 1905
3 600 KW 1906
Building sold 19[illegible]6 to Ralph Stark. Feeder cable between France Ave. and Hopkins removed 1947.
4

#25 Excelsior Division St. and the R/W, Excelsior 1905-1932
Building size: 42' x 74' or 40' x 72'. The operator's cottage: 24' x 30'.
1-2 600 KW 1905
3 600 KW 1906
Electricity was furnished to the Excelsior Amusement Park from 1925 to 1932. The building was demolished in 1933.

The three rotary converters from the Excelsior Substation were mvoed to storage at the Hopkins Substation in 1932. These six rotary converters were subsequently relocated.
Two from substation #23 to the Lake St. Substation in 1942.
Two, one each from substations #23 and #25, to the Minnehaha Substation in 1943.
One, Excelsior unit 2, was sold for scrap in 1946.
One, from Excelsior, to the College Ave. Substation for spare parts.

#24 Fair Oaks Terminal Pole
#26 Linwood Terminal Pole
#27 Big Island Substation
The A.C. transmission line to Big Island Park ran two miles overhead from Fair Oaks to Linwood, then ½ mile by submarine cable under Lake Minnetonka to the substation on the island. The 600 KW substation on the island provided electricty for lighting and power for the amusement features.

#28 Lowry (32nd Ave.) Lowry Ave. N. and 3rd St.N., Minneapolis 1908-1953
Building size: 43' x 48'.
1 1500 KW 1908
2 1500 KW 1910
Machinery only sold to Mid-Continent Development & Construction Co. Building sold to Northern States Power Co.

#29 Hope St. Hope St. and E. 7th St., St.Paul 1909-1952
Building size: 44' x 47'.
1 1500 KW 1909
2 1500 KW 1910
Construction Journals indicate that Unit 1 was College Ave. Substation original Unit 5 moved here in May 1909. In 1933 the Booster Set (Westinghouse motor and generator) from the Wildwood Substation was installed here and overhead feeder cable strung from the Hope St. Substation along E. 7th St. to Duluth Ave.

#30 Minnehaha 27th Ave. S. and 29th St. E., Minneapolis 1911-1953
Building size: 40' x 45'.
1 1500 KW 1911
2 1500 KW 1912
One Booster Set, consisting of one 400 h.p. motor with two 135 KW generators, from the Lower Dam Substation was installed here during April-June 1916 to provide extra capacity needed for the Motor Speedway service. Two 600 KW rotary converters from the Hopkins and Excelsior Substations were installed during 1943. Sold complete to Mid-Continent Development & Construction Co.

#31 University 4th St. S.E. and 2nd Ave. S.E., Minneapolis 1912-1954
Building size: 44' x 48'; attached Carhouse and Garage: 50' x 50'.
1-2 1500 KW each 1912
During 1947-1948 a 25' x 47' building addition was constructed and one 2000 KW [redacted] mercury arc rectifier installed. One 1500 KW rotary converter was simultaneously removed. Sold complete to the Mid-Continent Development & Construction Co.

#32 Girard Girard Ave.S. and Lake St. W., Minneapolis 1913-1954
Building size: 45' x 45'. Operator's cottage completed 1913.
1-2 1500 KW each 1913
Machinery only sold to Mid-Continent Development & Construction Co. Building sold to Northern States Power Co.

#33 Concord Concord St. and Isabel St., St.Paul 1917-1953
1 1500 KW 1917 College Ave. Substation Unit 6.
2 1500 KW 1919 College Ave. Substation Unit 5.
Automatic controls were installed during 1917. In 1920 a shed was built to house the Booster Set from the College Ave. Substation. During 1947 Unit 2 together with three transformers and reactances were moved to the 11th St. Substation. Disposition not known.

SUMMARY DESCRIPTION
1927

The Main Steam Station in Minneapolis contained six steam turbine-generator units with a total capacity of 74,850 KW. Coal requirements were 165,000 tons annually.

The Lower Dam and Hennepin Island Water Power Stations contained fourteen hydro-electric generators with a total capacity of 14,650 KW. The entire flow of the Mississippi River was used by the two plants.

Fourteen substations (one with automatic control) housed 39 rotary converters with a total capacity of 51,900 KW.

The distribution system consisted of approximately 200 miles of underground cable and approximately 300 miles of overhead feeder cable.

As of 4-5-1911 TCRT Co. had purchased 32 General Electric rotary converters.

```
 8  TC-8-600-525-600    (TC = 3 phase/Poles/KW/RPM/Volts)
 6  HC-8-600-575-600    (HC = 6 phase)
18  HC-16-1500-260-600
```

14 600 KW	
Lower Dam	4
Wildwood	2
Stillwater	2
Hopkins	3
Excelsior	3
	14
	==

18 1500 KW	
11th St.	4
Lake St.	2
Lowry	2
Minnehaha	2
	10
College Ave	4
Snelling	2
Hope St.	2
	8
	18
	==

A SIMPLE SYSTEM FOR NUMBERING FEEDER CABLES

ERJ VOL 32 —— #17 1908

The Twin City Rapid Transit Company has two water power and one steam generating statians feeding 11 sub-stations. A simple yet ingenious method for numbering the underground feeder cables connecting these various stations has been devised. Each power station is given a number from 1 to 10 inclusive. The distributing station, that is, those points from which main circuits from the power-house terminate or branch, or at which the construction of the circuits changes, are given numbers from 11 to 1,000. The independent numbers of the various lines are then made up as follows:

Line numbers:—

3-phase alternating-current lines—numbers consist of three parts:

1—The number of the station from which the line goes.

2—A letter distinguishing lines between the same stations.

3—The numbers of the station to which the line goes.

Examples: Lines between Power Station No. 1 and Distributing Station No. 11 are as follows: 1A11, 1B11, 1C11, etc.

600-volt positive feeders—Numbers consist of two parts:

1.—The number of station from which feeder goes.

2.—The relative number, 1 to 99 inclusive, of the feeder.

Example: Positive feeders from Station No. 11 are as follows: 11-1, 11-2, 11-3, etc.

Negative feeders.—Numbers consist of two parts:

1.—The number of the station from which the feeder goes.

2.—The relative number, 101 to 199 inclusive, of the feeder.

Example: Negative feeders from Station No. 11 are as follows: 11-101, 11-102, 11-103, etc.

Miscellaneous lines—that is, arc circuits, lighting circuits, etc., not covered by the above—numbers consist of two parts:

1.—The number of the station from which the line goes.

2.—The relative number, 201 to 299 inclusive, of the line.

Example: Miscellaneous lines from Station No. 27 are as follows: 27-201, 27-202, 27-203, etc.

With this system of station and line numbering it is possible for a line foreman to identify any cable by its number without the use of an elaborate set of charts or a book of distribution maps. Whenever cables or circuits are built the terminals at all switches and junction points are neatly lettered according to this system.

Como Park Excelsior Arc Light Dynamo

This machine was purchased by TCRT in 1894 from the Chicago Park Dept. and it had at that time been in service in Lincoln Park for several years. It was installed in the old Hill St. Power House in St.Paul, and when this station was abandoned in 1906 it was moved to the Snelling Substation, where it continued in faithful service until 1933. During all this time it was used to generate current for the arc lamps in Como Park. There were appproximately 150 lamps in the park, and as each required 50 volts for operation the voltage across the terminals of the machine was about 7500 volts. This arc-light machine was one of the earliest made and probably the last one used for outside lighting. When a new lighting system was installed in Como Park in 1933 it was donated by TCRT to Henry Ford's Edison Museum at Dearborn, Mich.

To those of us who had to care for and keep this old arc-light machine in repair the memories are not altogether pleasant. On stormy nights the old relic would get balky and shoot blue flames in the most unsuspected directions. Your reporter's (O. H. Erickson, Steam Plant) first job with TCRT was as lineman in Como Park and Load Dispatcher J. W. Simpson was at that time in charge at Snelling Substation. Al Swedblom, August Anderson, J. Rafferty, George Medved, Frank Carlson and many others will not begrudge Henry Ford the possession of this memorable machine. George Medved was more than once willing to send it to another famous place, together with all the pet names he could think of, and they were many.

BUS AND TROLLEY NEWS, October, 1937, published by the Twin City Lines Credit Union.

1-1-1920 St.Paul City Railway Valutaion
Substation Equipment
Substation no. 16 Snelling and University Avenues

Arc Light Generator: Exclesior Electric Company.
Specification no. 37 Serial no. 2440
7500 volts 650 r.p.m.
leather belting 14" wide, 53 lineal feet

LOWER DAM WATER POWER STATION CONTRACT

Between St.Anthony Falls Water Power Co. and Twin City Rapid Transit Co. Dated 12-5-1896. Term 40 years from 6-1-1897 (to 6-1-1937). Capacity of plant leased: 10,000 h.p. Seven of ten sets of waterwheels (7,000 h.p.) were to be completed as soon as possible at a maximum cost of $300,000. StAFWP Co. was to furnish and make all wire connections, both overhead and underground, and all machinery and apparatus to transmit the electricity produced by _______ h.p. to ________, together will all necessary appliances and connections in said powerhouse. TCRT Co. to furnish right-of-way free of cost.

3,000 h.p. to Hill St. Power House, St.Paul.
3,000 h.p. to Power House #1, Minneapolis. (3AN & 2AN)
1,000 h.p. to Power House #2, Minneapolis. (31st & Nicollet)

The three additional sets of waterwheels were to be installed during the next three years.

John S. Pillsbury signed as president of StAFWP Co., Charles A. Pillsbury as president of Minneapolis Mill Co., and for TCRT Co., Thomas Lowry, president, and C. G. Goodrich, secretary.

Terms of payment: basis of mechanical horsepower available at the shaft of the water wheels. This power was to be paid for whether used or not.

Up to 6,000 h.p.:	$23 per h.p. per year;
From 6,000 to 9,000 h.p.:	$10 per h.p. per year;
Above 9,000 h.p.:	Free.

StAFWP Co. was to maintain all hydraulic works including dams, rack and waterwheels themselves. TCRT Co. was to maintain all electrical equipment, including transmission cables and conduit, as well as operation of the electrical equipment.

A revision stated that the mechanical horsepower was now determined from the electrical horsepower. A test determined that the electrical efficiency of the generators was 95% for each KW generated, which represented 1.411 h.p. All depends upon the stage of the river, and the trend of the stage of the river. The stage can vary during the day.

HENNEPIN ISLAND WATER POWER STATION CONTRACT

Dated 1-2-1908. Term of lease: shall begin when plant is ready and continue until 6-1-1937. Minneapolis General Electric Co.'s lease with StAFWP Co. was dated 10-1-1907; Mpls. G.E. Co. had by assignment and agreement dated 12-19-1907 sold, assigned and conveyed, transferred and set over unto T.C.R.T. Co. (Lessee) that Lease Agreement dated 10-1-1907. Terms of payment: $80,000 per year. Subject to prior water rights of present Lessees of StAFWP Co. and Mpls. Mill Co.

StAFWP Co. was to construct the plant complete: (1) four units of a total 9,000 KW AC nominal rating; (2) two exciter units of 150 KW DC nominal rating each; (3) governing and controlling apparatus; and (4) switchboards and apparatus for quick and convenient operation of the tie cables. To be completed on or before 6-1-1908. Lessee to maintain and operate the plant.

Alfred F. Pillsbury signed as president for StAFWP Co., W.D. Washburn as president of Mpls. Mill Co., and for T.C.R.T. Co. C. G. Goodrich, vice president, and E. S. Pattee, secretary.

1906-1915 AVERAGE COST OF POWER

Main Steam Station: cost of power produced during 1915:	$ .005630 per KWH.
Lower Dam Water Power Station: 1906-1915:	$ .003907 per KWH.
Hennepin Island Water Power Station: 1909-1915:	$ .004324 per KWH.

LOWER DAM WATER POWER STATION
1906-1915 (10 Years) OUTPUT

Average monthly minimum	Dec-Jan-Feb (4 yrs Jan; 4 yrs Feb; 2 yrs Dec)	2690 KW.
Average monthly maximum	Apr-Aug (6 yrs May; 1 yr Apr; 1 yr Jul; 2 yrs Aug)	6160 KW.

HENNEPIN ISLAND WATER POWER STATION
1909-1915 MAXIMUM KW OUTPUT AVAILABLE

May 1909, April 1910:	8500 KW.
May 1911:	4000 KW.
May 1912, June 1914:	8000 KW.
July 1913:	7000 KW.
July 1915:	8800 KW.

YEAR 1915

Main Steam Station	74,995,725 KWH	8,561 (*)
Lower Dam Water Power Station	43,700,485 KWH	4,989 (*)
Hennepin Island Water Power Station	30,709,050 KWH	3,505 (*)
Totals	149,405,260 KWH	17,055 (*)

(*) There was no caption for this column so we don't know what they represent.

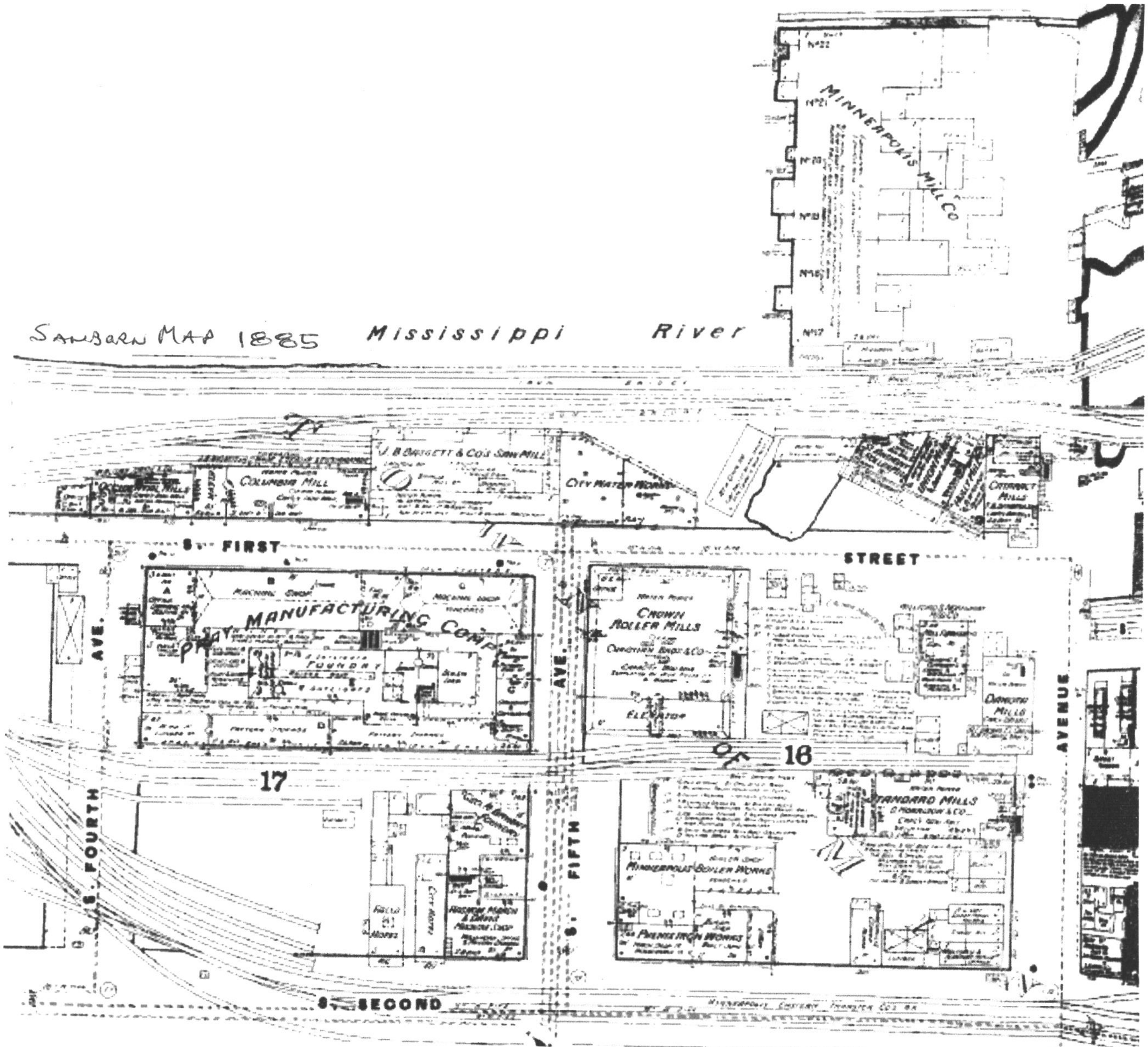
The Lower Dam Station operated 24 hours per day. Both the Main Steam Station and the Hennepin Island Station operated 21 hours per day, from 5 a.m. to 2 a.m.; with very little operation between 1 a.m. and 2 a.m., and with some operation between 5 a.m. and 6 a.m., and between 12 midnight and 1 a.m.

The Minneapolis and St. Paul Street Railway System.

A few months since, when the news was flashed across the continent that a great street railway corporation, after contracting for the building of a system of cable railways in Minneapolis and St. Paul, part of the required material having been delivered, had turned about and adopted an electrical system simply on the score of economy of maintenance and operation, there were but few street railway men who did not realize what an extraordinary undertaking this was. To-day over twenty miles of track are laid with a new 78-pound rail, the roadbed is cleaned up, and unless serious interruption occurs the motor cars will be running over fully 130 miles of track before November first. Nearly 800 men are employed on the Minneapolis end alone. The overhead trolley wire is being suspended from the curved bracket arms of handsome Walworth hollow iron poles that are placed in the center space between the two sets of tracks. This feature does away entirely with the use of supporting wires spanning the roadway. The heavy feeders are drawn into one-inch tubes, previously placed in square frame boxes and an insulating compound poured over and around the contents till the tubes are joined in one solid mass. This box is placed in the center space between the rails and the feeder wires brought to the surface through junction tubes and carried up within the hollow iron poles. Over 750,000 feet of tubing will be furnished by the Interior Conduit and Insulation Company for this installation, one conduit box on the main line holding 56 tubes. Too much credit cannot be given to Colonel Lowry and his able assistant, Mr. Clift Wise, for thus doing away with both the overhead feeders and the span wires.

The Sprague motors of 15 h. p. each are already at hand and are being placed in position on the cars, while the 200 h. p. Edison generators are now en route. Both the Minneapolis and the St. Paul power houses are nearing completion, the foundations for the three 1,000 h. p. Allis-Corliss engines, and for the 270 h. p. Babcock & Wilcox boilers are completed, and one of the engines will be set up this week. As the distance from the river is but a short one, the water required in the St. Paul power house will be drawn through an iron pipe. But in Minneapolis a tunnel 1,600 feet long and six feet in height is being excavated from the power house to the water, at which point it is expected to be ten feet below the river bed, and through this tunnel, which is located 50 feet below the street surface, a constant and ample supply of water can be secured at a moderate expense.

When the entire line is in operation it is expected that a rate of speed can be easily maintained between the outskirts of the two cities that will make this the most popular passenger route, an expectation that is already being anticipated as shown by the great increase in dwellings along the line and the steady rise in value of real estate. In fact, the property owners look upon the completion of the line as a mammoth enterprise deserving the highest commendation. In this connection it may be well to add that it is rumored that Mr. Villard is behind a deal to consolidate the St. Paul Gas Light Company, the St. Paul Edison Company and possibly the Minneapolis Edison Company, and that he proposes to erect a station of great capacity close to the river in St. Paul and supply arc and incandescent lights and current for small motors, and also to furnish all the current required in operating the St. Paul electric railway system. A suitable field for the gigantic energy of Mr. Villard seems to be presented in this case, as in the other enterprise concerning which rumor has been rife.


SANBORN MAP 1885

MINNEAPOLIS STREET RAILWAY POWER HOUSES
Compiled from Minneapolis Tribune Articles

3-21-1890: Contract with E. P. Allis & Co. for three 1,000 h.p. engines for 3rd Ave. N. Powerhouse.

9-14-1890: The flywheel for one1,000 h.p. engine is 84 ft. in circumference, 28 ft. in diameter, rim 6' 2" wide. Will be started tomorrow to supply power for Washington Ave., 1st Ave. S. and 4th Ave. S. lines.

10-8-1890: Power for all three lines is now furnished from 3rd Ave. N. powerhouse, the transfer from the Thomson-Houston Electric Company being made yesterday.

10-9-1890: Have placed a contract with Edison General Electric Co. of New York for 15 Edison #60 Dynamos of 150 kw (200 h.p.) each .

8-2-1891: Oil tanks are being constructed at the rear of the powerhouse. A connecting switch with the Great Northern tracks is being built over which oil will be brought to the tanks. 8-2-1891: During the present week tracks will be laid to the new oil tanks. Oct. 1891: laying track.

10-11-1891: Two Stirling Boilers (600 h.p. each) have arrived. [Nicollet & 32nd St. powerhouse]

11-1-1891: Five Westinghouse Engines (250 h.p. each) have just been received. [Nicollet & 32nd St. powerhouse] The carhouse built two years ago, will be extended by the addition of an engine room. Will be equipped with five 235 h.p. Dynamos and five Boilers.

12-20-1891: Purchased five more Westinghouse Engines (200 h.p. each for the 32nd St. powerhouse.

1-1-1892: The system at present requires two powerhouses and 13 engines, two of 1,000 h.p. each, one of 500 h.p., and 10 of 250 h.p. each.

3-9-1892: The new power house at Thirty-First St. will be put in operation April 1st and then the company will control engines having a total capacity of 5,600 h.p. This new plant will be complete in every detail. The 10 big engines are now in place and await only the necessary connection with the steam plant. About 100 men will be employed in and around the plant.

1-1-1893: The powerhouse at 3rd Ave. N. and 2nd St. N. has three Corliss Engines and three Generators. The Boilers use three tank cars of oil per day. The powerhouse at 32nd St. and Nicollet Ave. is a reserve power station; 10 Engines of 300 h.p. each.

BABCOCK & WILCOX BOILERS

ARE IN USE IN THE FOLLOWING PLANTS IN THE STREET RAILWAY FIELD.

ELECTRIC RAILWAYS.

		Boilers.	*H. P.*
WEST END STREET RAILWAY CO., Boston, Mass.	3 orders, 1889–1890,	26	6,500
THE MERRIMAC VALLEY STREET RAILWAY CO., Lawrence, Mass.	2 " 1891–1892,	3	480
THE PORTLAND STREET RAILWAY CO., Portland, Me.	April, 1891,	2	250
GLOBE STREET RAILWAY CO., Fall River, Mass	1892,	3	675
LYNN & BOSTON RAILROAD, Lynn, Mass.	Jan., 1892,	6	1,500
" " " Chelsea, Mass.	"	6	1,500
HARLEM BRIDGE, MORRISANIA & FORDHAM RAILROAD, New York City	"	4	1,000
BROOKLYN CITY RAILROAD CO., Brooklyn, N. Y	2 orders, 1891–1892,	16	5,000
ATLANTIC AVENUE RAILROAD CO., Brooklyn, N. Y.	April, 1892,	6	1,500
THE ALBANY RAILWAY, Albany, N. Y.	2 orders, 1889–1892,	6	750
TROY & LANSINGBURG RAILROAD CO., Troy, N. Y.	3 " 1889–1891,	5	864
ROCHESTER RAILWAY CO., Rochester, N. Y.	2 " 1891–1892,	2	808
CROSSTOWN STREET RAILWAY CO., Buffalo, N. Y.	Aug., 1890,	4	1,000
SEA SHORE ELECTRIC RAILWAY CO., Asbury Park, N. J	March, 1892,	2	640
PITTSBURGH & BIRMINGHAM TRACTION CO., Pittsburgh, Pa	July, 1890,	4	1,000
BRADDOCK ELECTRIC RAILWAY CO., Braddock, Pa	July, 1891,	1	164
ECKINGTON & SOLDIERS' HOME RAILROAD CO., Washington, D. C	Jan., 1889,	1	136
GLEN ECHO RAILWAY CO., Washington, D. C	2 orders, 1890–1891,	3	312
ROCK CREEK RAILWAY CO., Washington, D. C	Sept., 1890,	3	375
THE CINCINNATI STREET RAILWAY CO., Cincinnati, O.	2 orders, 1890,	5	1,500
COLUMBUS CONSOLIDATED STREET RAILROAD CO., Columbus, O.	2 " 1890–1891,	6	1,076
CITIZENS' STREET RAILWAY CO., Indianapolis, Ind	Aug., 1891,	2	600
AURORA STREET RAILWAY CO., Aurora, Ill	2 orders, 1890–1891,	4	832
STREATOR RAILWAY CO., Streator, Ill	April, 1890,	2	208
NEGAUNEE & ISHPEMING STREET RAILWAY CO., Negaunee, Mich	Sept., 1891,	2	208
THE DOUGLAS COUNTY STREET RAILWAY CO., Superior, Wis.	June, 1891,	3	445
ST. PAUL CITY RAILWAY, St. Paul, Minn.	April, 1890,	8	2,176
DULUTH STREET RAILWAY CO., Duluth, Minn.	3 orders, 1890–1892,	7	1,072
ST. PAUL & WHITE BEAR RAILWAY, North St. Paul, Minn.	March, 1892,	2	184
PEOPLE'S STREET RAILWAY, St. Joseph, Mo.	May, 1889,	4	832
THE NORTHEAST RAILWAY CO., Kansas City, Mo.	Sept., 1889,	2	250
THE AUGUSTA RAILWAY CO., Augusta, Ga.	March, 1890,	1	150
THE COAST LINE RAILWAY, Savannah, Ga.	March, 1892,	2	500
CITIZENS' RAILWAY CO., Waco, Tex.	Aug., 1890,	2	240
TACOMA RAILWAY & MOTOR CO., Tacoma, Wash.	May, 1890,	4	656
BILBAO ELECTRIC TRAMWAYS, Bilbao, Spain	Feb., 1889,	2	146
EAGLEHAWK ELECTRIC TRAMWAY CO., Sandhurst, Victoria, N. S. W	April, 1889,	3	90

CABLE AND TRACTION TRAMWAYS.

		Boilers.	*H. P.*
NEW YORK & BROOKLYN BRIDGE, Brooklyn, N. Y.	3 orders, 1882–1891,	12	1,248
WASHINGTON & GEORGETOWN RAILROAD, Washington, D. C.	3 " 1889–1891,	13	1,956
CLEVELAND CITY CABLE RAILWAY CO., Cleveland, O	March, 1890,	3	1,086
THE VALLEY CITY STREET & CABLE RAILWAY CO., Grand Rapids, Mich	April, 1891,	4	781
CHICAGO CITY RAILROAD, Chicago, Ill	April, 1881,	4	1,000
ST. PAUL CITY RAILWAY CO., St. Paul, Minn	2 orders, 1888–1890,	11	2,800
MINNEAPOLIS STREET RAILWAY CO., Minneapolis, Minn.	Sept., 1889,	5	1,360
GRAND AVENUE RAILWAY CO., Kansas City, Mo	2 orders, 1886–1888,	4	800
METROPOLITAN STREET RAILWAY CO., Kansas City, Mo.	3 " 1886–1888,	9	1,800
INTERSTATE CONSOLID'T'D RAPID TRANSIT RAILWAY CO., Kansas City, Mo.	Aug., 1887,	2	400
PEOPLE'S CABLE RAILWAY CO., Kansas City, Mo	Aug., 1887,	3	600
HOLMES STREET RAILWAY CO., Kansas City, Mo.	Feb., 1889,	2	350
DENVER CITY CABLE RAILWAY CO., Denver, Col	2 orders, 1889–1891,	4	1,600
HOUSTON CITY STREET RAILWAY CO., Houston, Tex	2 " 1890–1892,	3	492
MARKET STREET CABLE RAILWAY, San Francisco, Cal	2 " 1882–1887,	6	1,500
PIEDMONT CABLE CO., San Francisco, Cal	July, 1889,	3	438
CALIFORNIA STREET CABLE CO., San Francisco, Cal.	May, 1890,	3	360
PATENT CABLE TRAMWAY CORPORATION, Highgate, London, England	2 orders, 1883–1884,	3	153
EDINBURGH NORTHERN CABLE TRAMWAY, Edinburgh, Scotland	2 " 1886–1891,	1	400
COMPAGNIE DES LOCOMOTIVES SANS FOYER, Courbevoie, France.	Jan., 1889,	2	156
" " " " Nord de la Seine, St. Germain, France.	May, 1889,	2	171
COMPAGNIE DES TRAMWAYS DU DÉPARTEMENT DU NORD, Roubaix, France.	June, 1886,	3	135
COMPAGNIE DES OMNIBUS ET TRAMWAY, Lyons, France.	2 orders, 1887–1888,	3	152
THE MELBOURNE TRAMWAYS, Richmond Line, Australia, Melbourne	Nov., 1884,	6	1,040
" " " Fitzroy Line, " "	July, 1885,		

THE BABCOCK & WILCOX CO.,

30 Cortlandt Street, **New York.**

THE EDWARD P. ALLIS COMPANY,

1892

MILWAUKEE, WISCONSIN,

Have Furnished **REYNOLDS-CORLISS ENGINES** *as Follows*

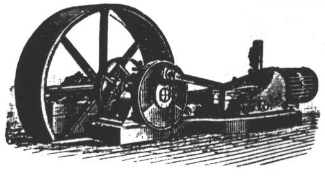
FOR OPERATING

Cable and Electric Street Railways:

8	Triple Exp. Engines,	1,000 H. P.	each...	Boston, Mass.
1	" Engine,	500 "	....	"
3	" Engines,	1,000 "	each...	St. Paul, Minn.
2	" "	1,000 "	" ...	Minneapolis, Minn.
4	" "	550 "	" ...	St. Paul, Minn.
2	Engines	650 "	" ...	Kansas City, Mo.
1	Engine	450 "	....	Omaha, Neb.
1	"	250 "	....	"
1	"	450 "	....	Cleveland, Ohio.
3	Engines	250 "	each...	"
1	Engine	400 "	....	Peoria, Ill.
1	"	300 "	....	"
1	"	400 "	....	Topeka, Kas.
1	"	300 "	....	"
1	"	350 "	....	Sioux City, Iowa.
1	"	250 "	....	" "
2	Compound Engines...	300 "	each...	Washington, D. C.
1	Engine	250 "	....	Nashville, Tenn.
1	Compound Engine,	300 H. P.	....	Duluth, Minn.
1	"	350 "	....	Milwaukee, Wis.
1	"	250 "	....	"
1	"	200 "	....	"
2	Engines	300 "	each....	Pueblo, Colo.
1	Engine	300 "	....	Seattle, Wash.
2	Engines	300 "	each....	Lancaster, Pa.
2	"	250 "	"	Youngstown, O.
1	Engine	250 "	....	South Bend, Ind.
2	Engines	250 "	each....	Seattle, Wash.
1	Engine	150 "	....	Ottawa, Ill.
1	"	150 "	....	West Bay City, Mich.
1	Compound Engine,	200 "	....	Houston, Texas.
2	Engines	125 "	each....	Colorado Springs, Colo.
2	"	100 "	"	Ottumwa, Iowa.
1	Engine	100 "	....	Butte, Mont.
1	"	40 "	....	Omaha, Neb.

CATALOGUES FURNISHED ON APPLICATION.

The Buckeye Automatic Cut-Off Engines.



SLOW SPEED, MEDIUM SPEED

. . . AND . .

* HIGH SPEED ENGINES. *

SIMPLE, COMPOUND AND TRIPLE EXPANSION ENGINES.

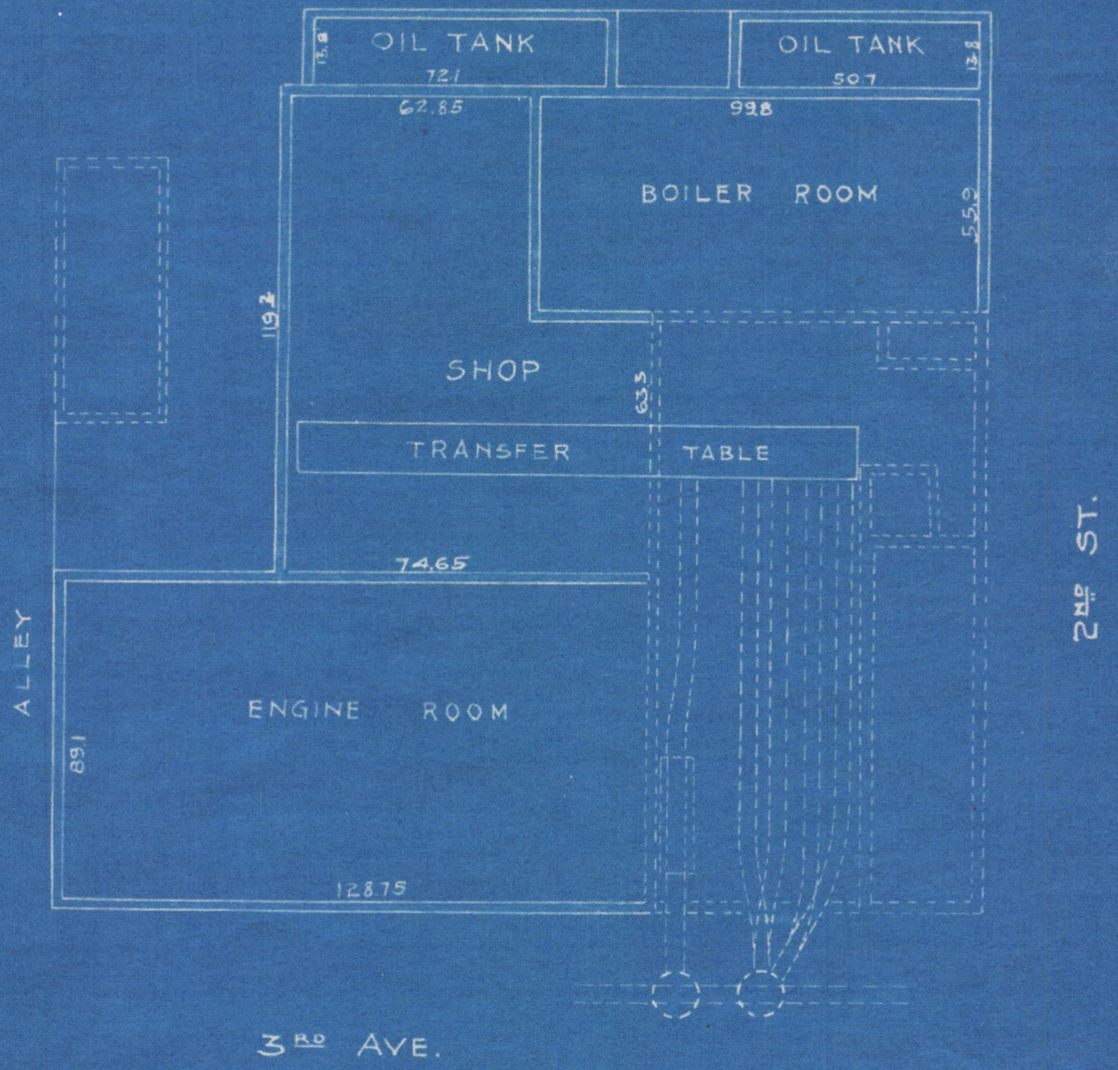
HIGH PRESSURE BOILERS.

Complete Steam Power Plants of Highest Attainable Efficiency.

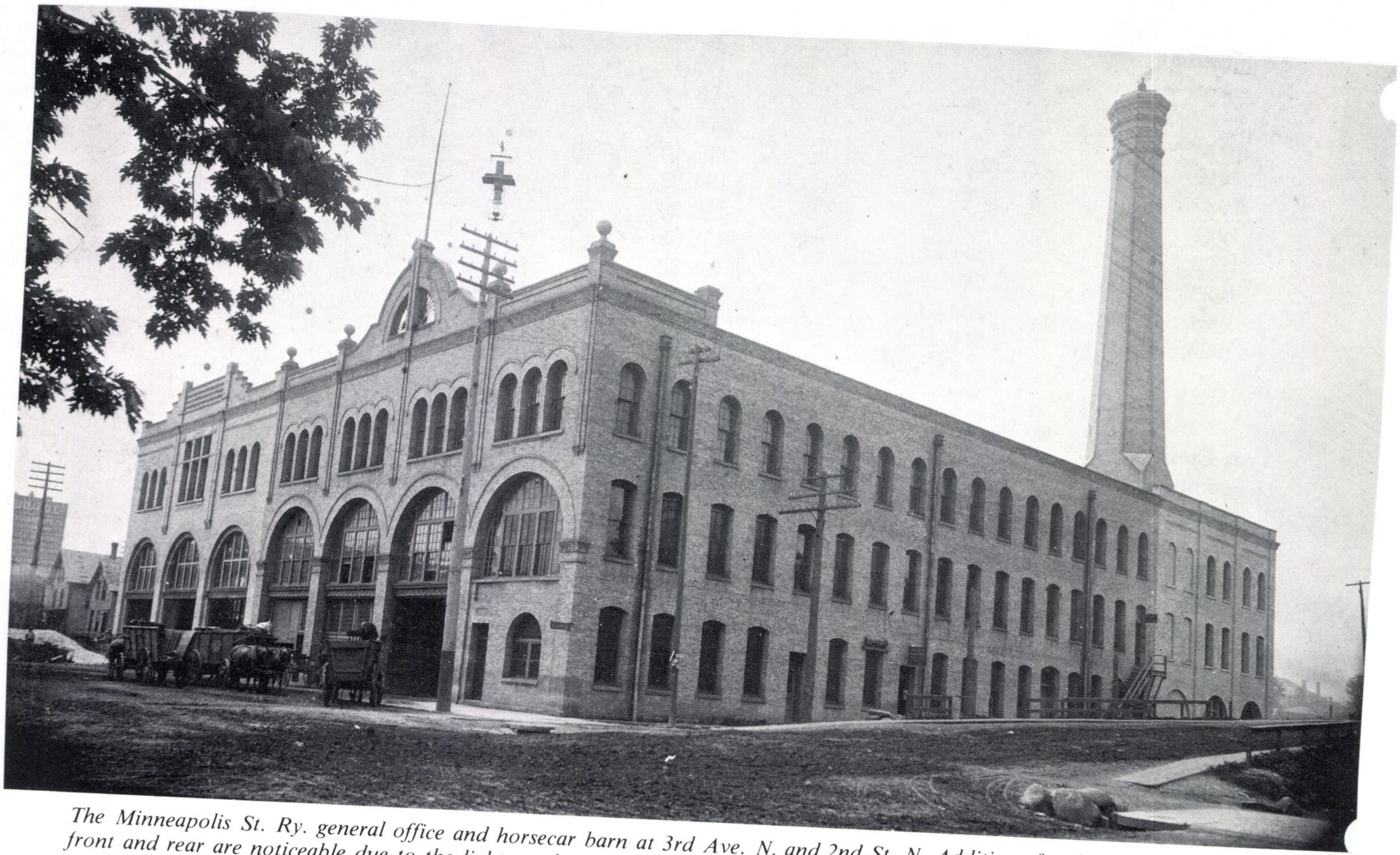
Address, BUCKEYE ENGINE CO., Salem, Ohio,

Or, SALES AGENTS:

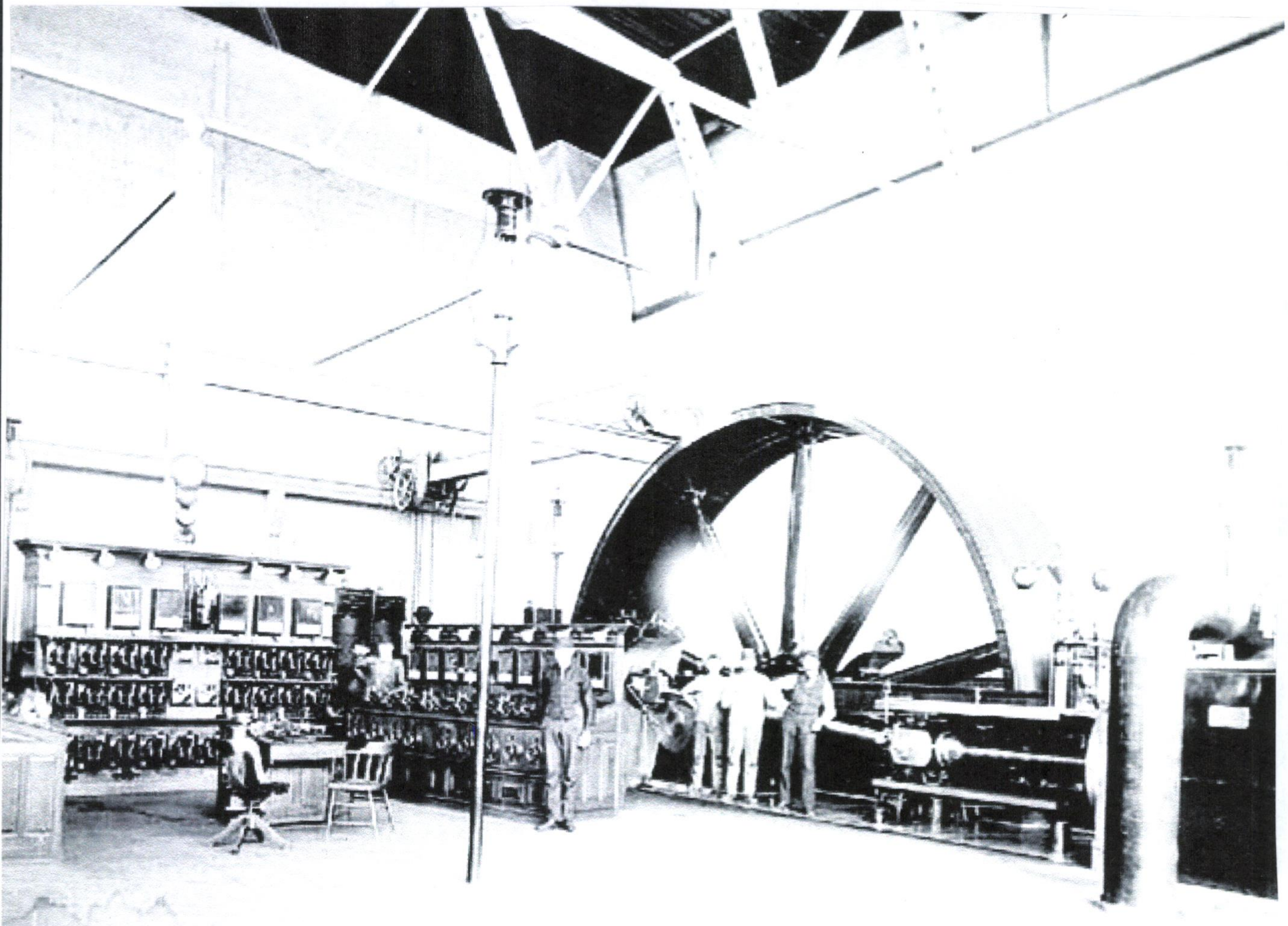
ROBINSON-CARY CO., St. Paul, Minn.
N. W. ROBINSON, 97 Washington Street, Chicago, Ill.
JAS. CREIGHTON, 635 First Street, Louisville, Ky.
CHATTANOOGA SAW WORKS, Chattanooga, Tenn.
BUCKEYE ENGINE CO., Sales Agency, No. 10 Telephone Building, New York City.


OIL TANK
13.8
72.1
OIL TANK
50.7
13.8
62.85
99.8
BOILER ROOM
55.9
119.2
SHOP
63.3
TRANSFER TABLE
74.65
ALLEY
ENGINE ROOM
89.1
128.75
2ND ST.
3RD AVE.

BUILDINGS
SHOPS & GENERAL OFFICES
3RD AVE NO AND 2ND ST
HORSE CAR LINES
MINNEAPOLIS STREET RAILWAY CO



The Minneapolis St. Ry. general office and horsecar barn at 3rd Ave. N. and 2nd St. N. Additions for the powerhouse at the front and rear are noticeable due to the lighter color of the brick. (Robert Bowes collection)



St. Paul—Minneapolis Electric Street Railway System.

The twin cities of the Northwest, Minneapolis and St. Paul, possess a system of street railways which ranks amongst the largest in this country. Although the roads in the two cities were originally built, and have been until recently operated as separate and distinct systems, it is most interesting to note the similarity in the main points of construction in the two systems.

At the present time the corporation which controls all the lines in the two cities is officered as follows: Thomas Lowry, president; C. G. Goodrich, vice-president and general manager Minneapolis Street Railway, and A. L. Scott general manager St. Paul City Railway.

With slight exceptions the centre pole construction is in use throughout, iron poles being employed in the business streets and interurban line, and octagonal wooden poles in the suburban and outlying districts. All current is supplied by Edison generators, and Edison motors are largely used, though not exclusively, the Thomson-Houston being represented to a considerable extent. In all, nearly 225 miles of double track is in daily operation, of which 125 is in the corporate limits of Minneapolis and 100 in St. Paul.

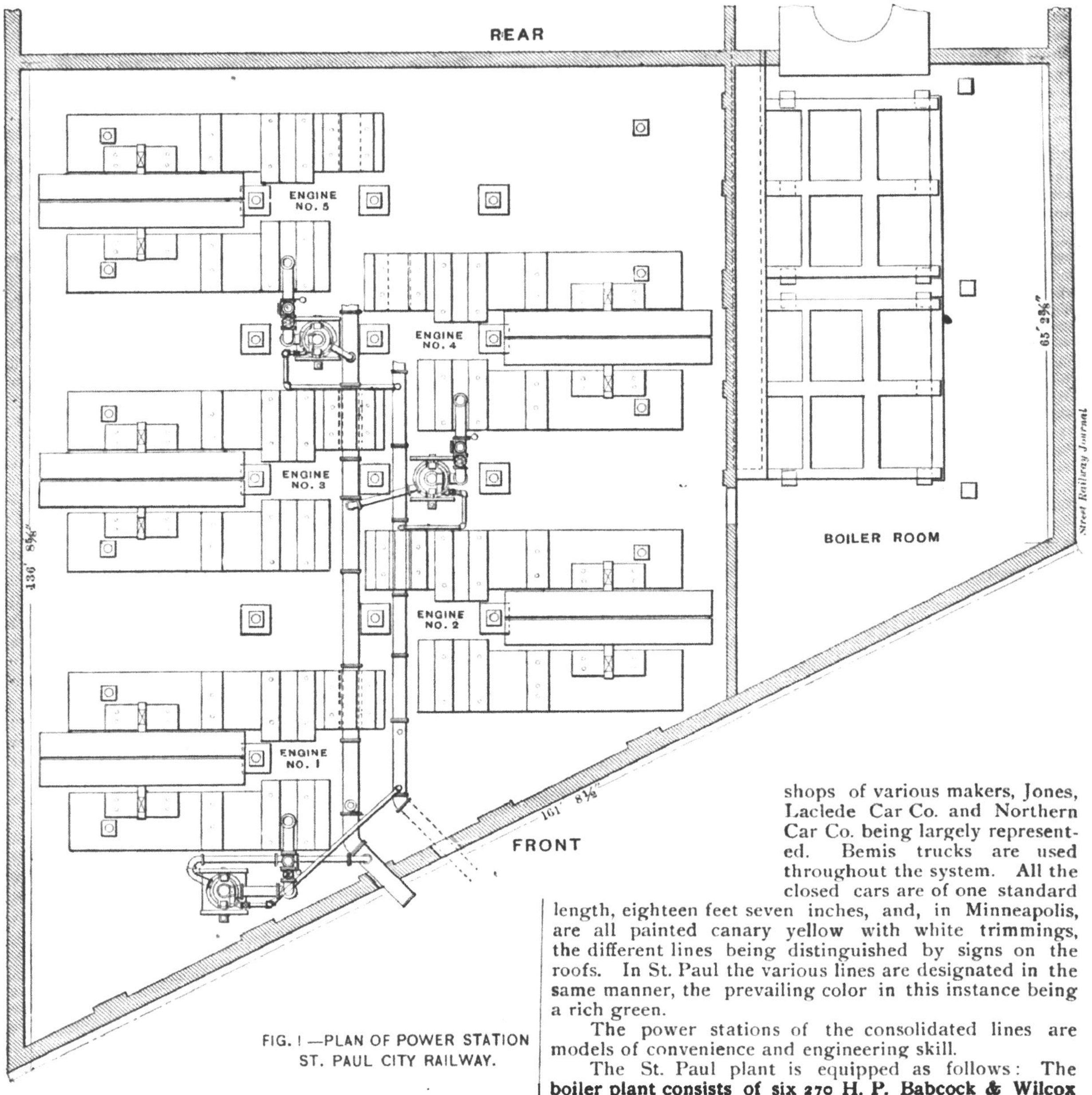


FIG. 1 —PLAN OF POWER STATION ST. PAUL CITY RAILWAY.

In the road construction, girder and T rails, made by the Johnson Co., are being used. The weight of rails varies somewhat, being influenced by the traffic, but all lie within the limits of sixty pounds for the minimum and 100 lbs for the maximum.

The number of cars in daily operation, of course, changes according to the exigencies of the traffic, but a fair average may be taken as about 130 cars in St. Paul, and about 250 in Minneapolis. These cars are from the shops of various makers, Jones, Laclede Car Co. and Northern Car Co. being largely represented. Bemis trucks are used throughout the system. All the closed cars are of one standard length, eighteen feet seven inches, and, in Minneapolis, are all painted canary yellow with white trimmings, the different lines being distinguished by signs on the roofs. In St. Paul the various lines are designated in the same manner, the prevailing color in this instance being a rich green.

The power stations of the consolidated lines are models of convenience and engineering skill.

The St. Paul plant is equipped as follows: The boiler plant consists of six 270 H. P. Babcock & Wilcox boilers fitted with crude oil burners. As auxiliary to these and part of the steam plant are the necessary circulating pumps for oil and water, which are of various makes and types. In the engine room are three 900 H. P. condensing triple expansion engines made by the E. P. Allis Co., of Milwaukee. This latter firm furnished the plans for this station and the arrangement of shafting, clutches and belts, which are shown in the detailed drawing, Fig. 1, accompanying this article.

The station is most complete in every detail and embraces all the essentials of power transmission. The clutches are of the Hill company's manufacture and are

Digitized by Google

so placed that all four generators may be run singly or in concert without unnecessary friction of shafting. The air pumps for each engine are situated in pits beneath the floor line of the engine room. The ultimate capacity of the station, when all the engines are in place, will be 45,00 H. P.

The use of oil for fuel has proved quite satisfactory and productive of excellent results as regards labor, the absence of ashes, the ability to maintain a uniform pressure and the high efficiency attained by the boilers. The method of obtaining a constant pressure of oil, devised by Engineer Larkin, is worthy of more than passing notice. As will be seen by the accompanying sketch, Fig. 5, the oil tank is located beneath the floor of the boiler room, and the pump discharges into a standpipe fitted with an overflow, so that the oil reaches the burners at a constant pressure under an eighteen feet head. The daily consumption is about 4,500 gals.

The dynamos are of the Edison 150 kilowatt type, arranged in groups of four, and are situated on the floor above the engines. The interior of the dynamo room is shown in Fig. 5. The dynamo station does not differ materially from the many erected by the Edison General Electric Co., but it is characterized by the most scrupulous cleanliness, and orderly appearance.

The Minneapolis station is arranged upon a somewhat different plan, as is shown by the accompanying drawing, Fig. 6.

The boiler plant shown in Fig. 7 is composed of five 275 H. P. Babcock & Wilcox boilers, fitted with oil burners, carrying a pressure of 135 lbs. per square inch. The circulating pumps are of various types, including the Deane, Hall and Knowles makes.

The plan of the engine room is fully set forth in the engraving. The engines are triple expansion condensing engines, made by the E. P. Allis Co. of Milwaukee, and have been worked as high as 1,500 H. P. each. The condensers are grouped and are entirely separated from the main engine room.

In the upper floors of the main station are the general offices and woodworking and paint shops. The dimensions of the station are 218 × 200 ft., three stories high. The generators are sixteen in number and are, like those at St. Paul, of the Edison 150 kilowatt type. The switchboard, shown in Fig. 9, is not complete at present, but when finished will be second to none in the country for utility and convenience.

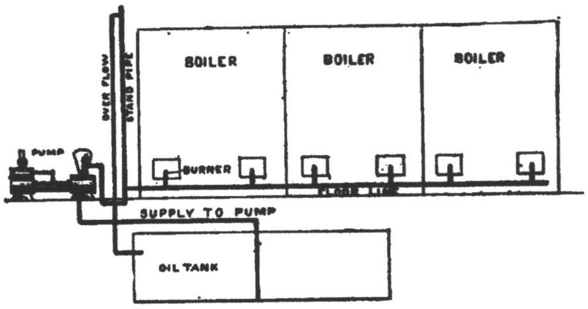


FIG. 3.—OIL PIPE CONNECTIONS ST. PAUL ELECTRIC RAILWAY STATION.

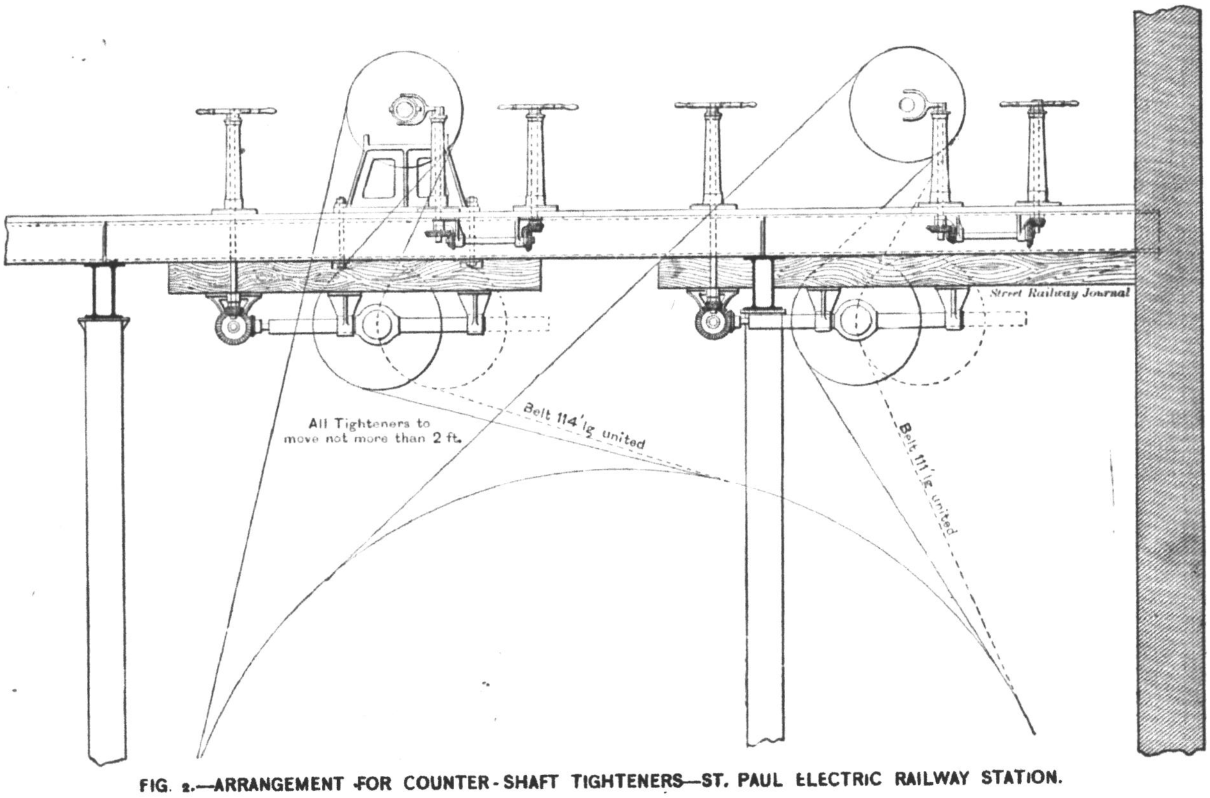


FIG. 2.—ARRANGEMENT FOR COUNTER-SHAFT TIGHTENERS—ST. PAUL ELECTRIC RAILWAY STATION.

The machine shop, situated in the main power station at Second Street and Third Avenue north, is unusually large and is equipped with all the necessary machine tools for making all repairs. The company also manufacture all of the gears in use on these cars. Ample provision has been made for the repairing of both motors and trucks. In fact this department of the road has a capacity far in excess of many pretentious manufacturing concerns.

To illustrate this point, two sprinkling cars, one of which is shown in Fig. 10, have recently been completed in the shops. These cars are an innovation and will, no doubt, be extensively adopted by many of the larger roads throughout the country. The tank is made of boiler iron and has a capacity of ninety barrels. This is mounted upon a flat car and is provided with a swinging arm which projects beyond the track and sprinkles the roadway. In addition to this, provision has been made

Digitized by Google

for sprinkling the track proper. It is proposed to draw this car at a good speed by a motor car.

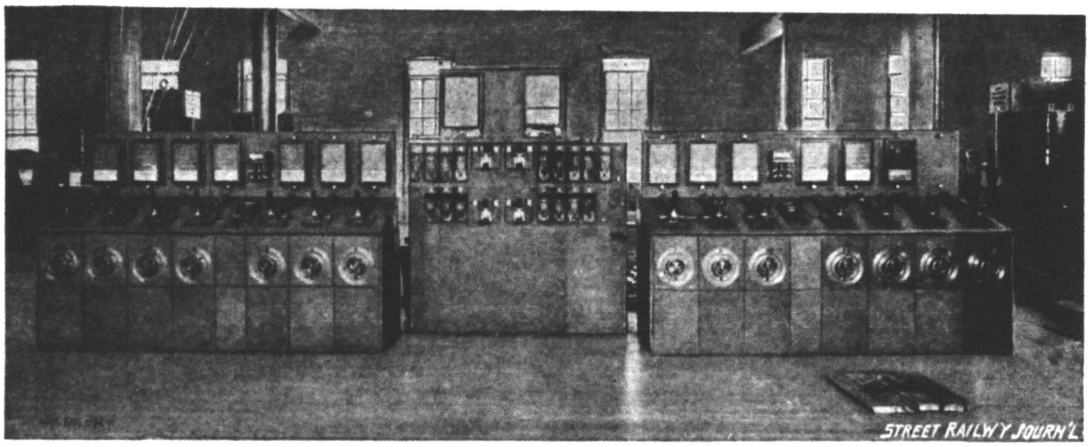


FIG. 4.—SWITCH BOARD—ST. PAUL ELECTRIC RAILWAY STATION.

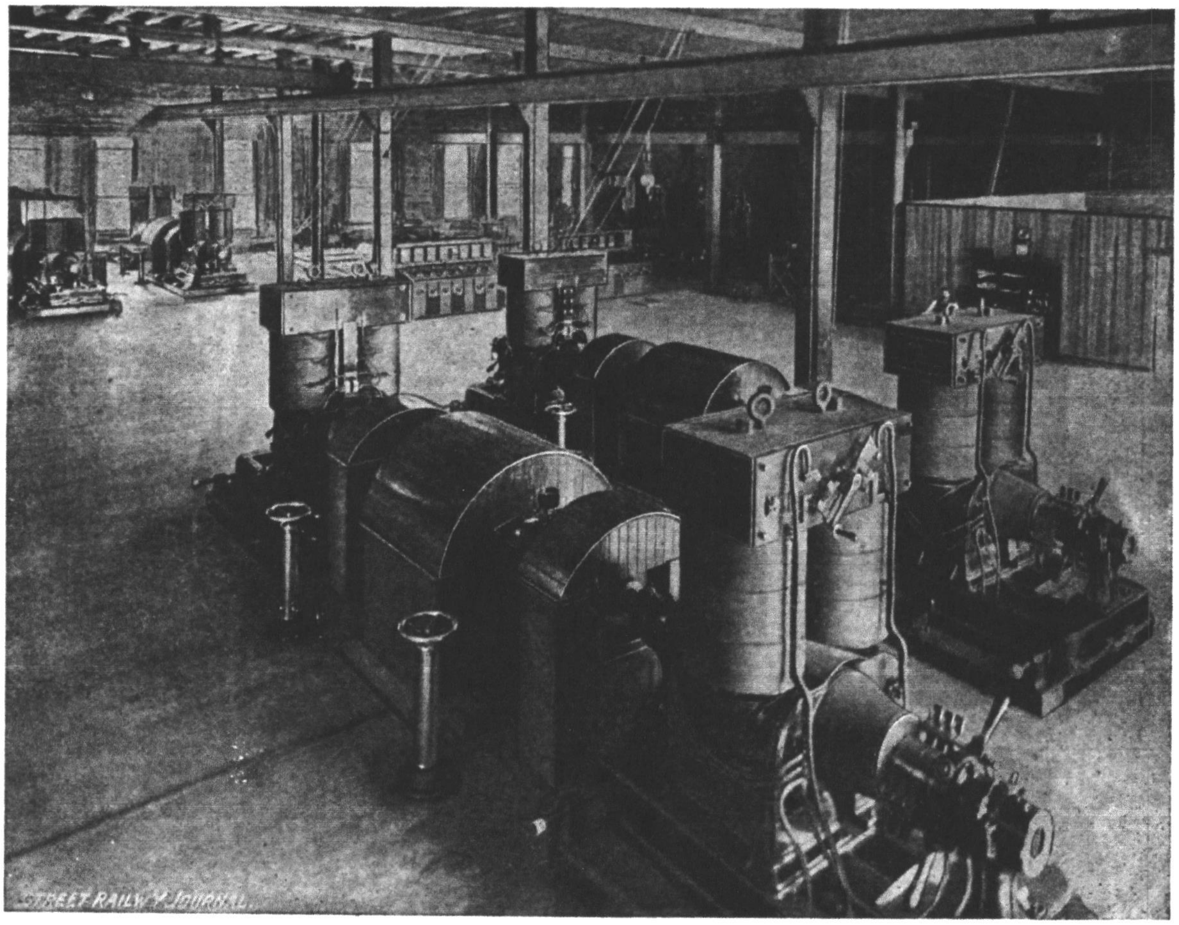


FIG. 5.—INTERIOR OF DYNAMO ROOM—ST. PAUL ELECTRIC RAILWAY STATION.

The car house of the Minneapolis system, of which a one-half front view is shown in Fig. 11, is 330 ft. front on First Avenue, northeast, by 200 ft. deep, and contains thirty tracks. The half toward Fourth Street, northeast, is provided with pits under each track for the cleaning and repairing of motors. In order to obtain as many tracks as possible, and at the same time allow the cars to enter the building squarely, the house was set back ten feet from building line, and provided with a ten foot vestibule, giving thereby fifty-five feet between the nearest track and the doors.

The set of curves laid for entering this car house, was designed by engineer W. F. Carr, of the Minneapolis Street Railway Co., and is shown in Fig. 12. This plan shows the main line on Central Avenue and its connecting track, with the loop and car house track, the inside curve being used exclusively as a loop for all East side cars, the outside for cars only when entering or going out from car house.

As shown, one-half of the entrance curves enter from

Digitized by Google

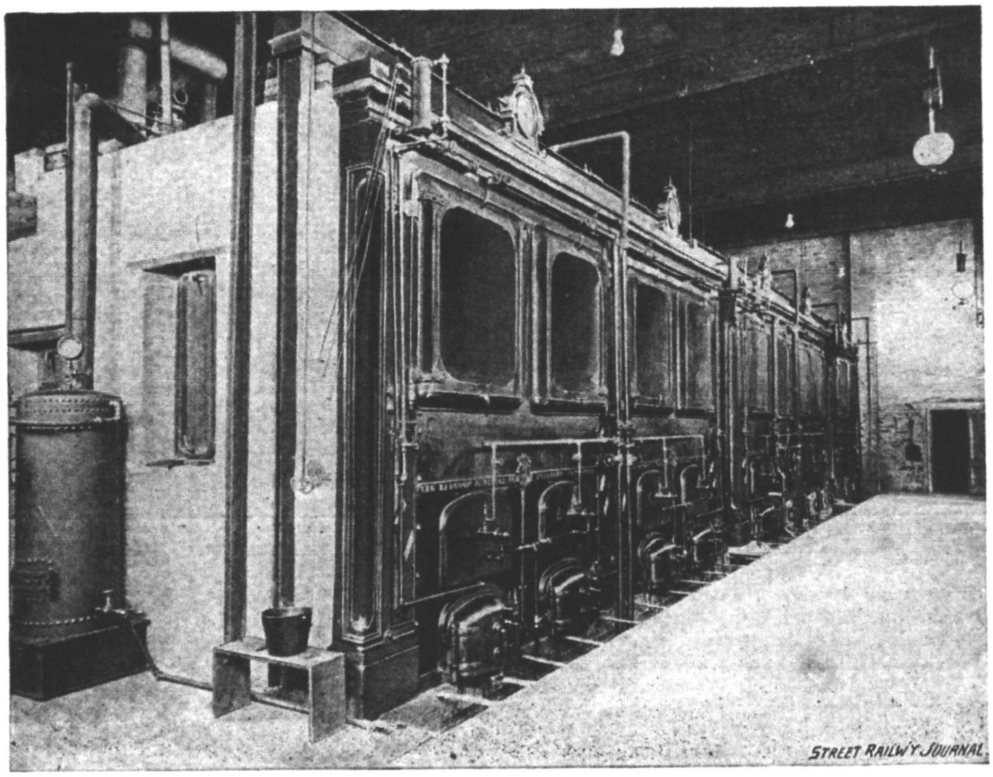

STREET RAILWY JOURNAL

FIG. 7—BOILER ROOM—MINNEAPOLIS ELECTRIC RAILWAY STATION.

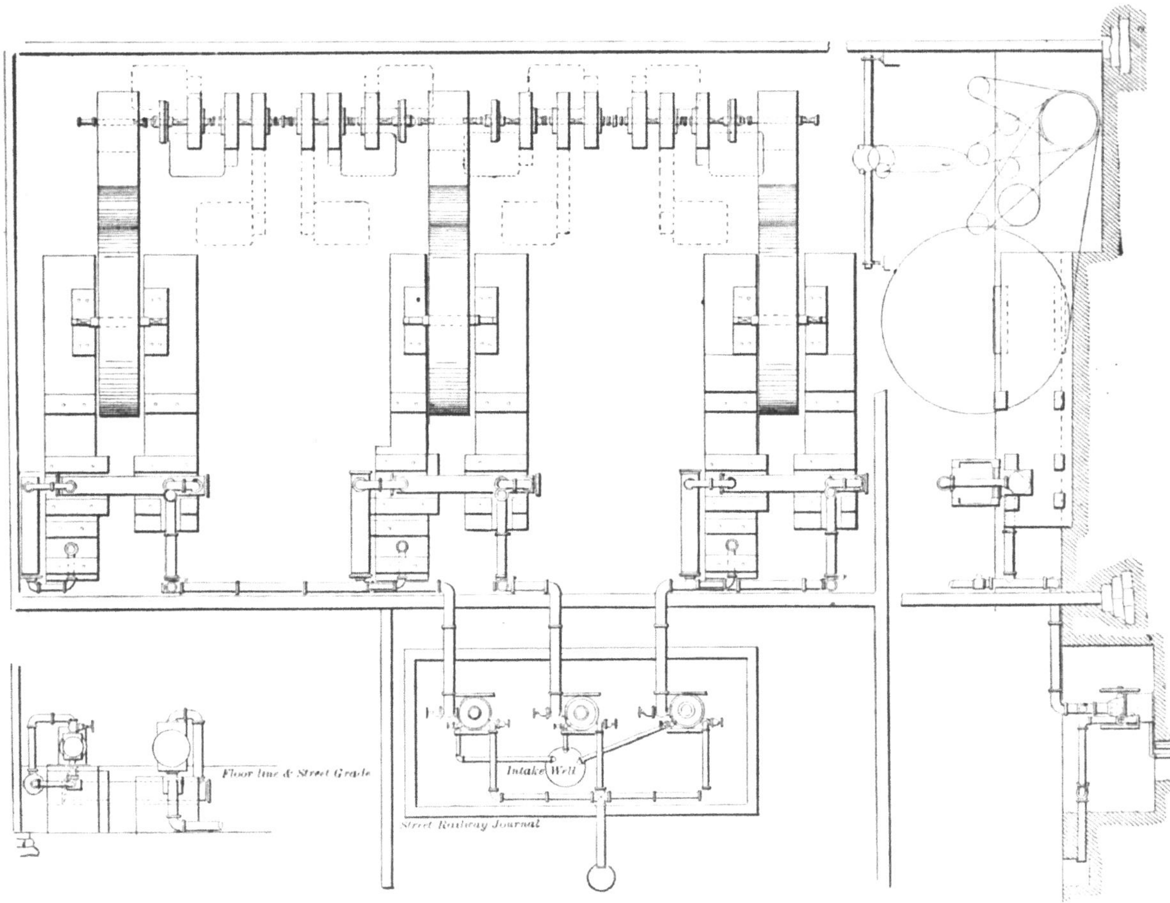

Floor line & Street Grade
Intake Well
Street Railway Journal

FIG. 6.—PLAN OF POWER STATION—MINNEAPOLIS STREET RAILWAY.

Digitized by Google

Fourth Street, northeast, the other half from Third Street, northeast, each half consisting of five sets of curves, and each set of three single curves. All sets of curves converge so as to join the main track with a single switch and mate, and are identical in every respect, having the same radii, tangents, switches, frogs, etc.

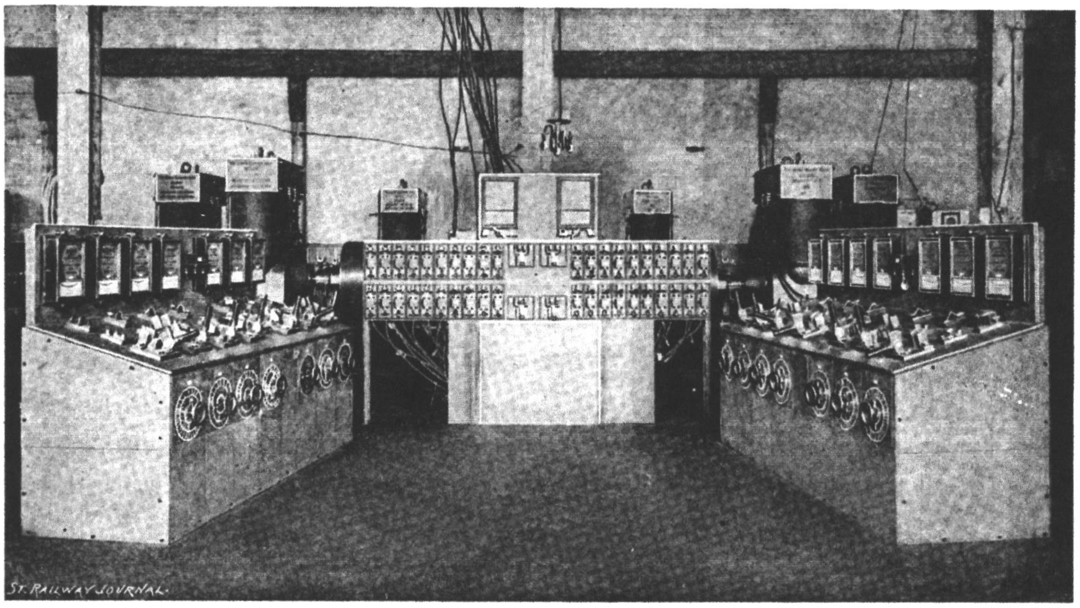


FIG. 9—SWITCH BOARD—MINNEAPOLIS ELECTRIC RAILWAY STATION.

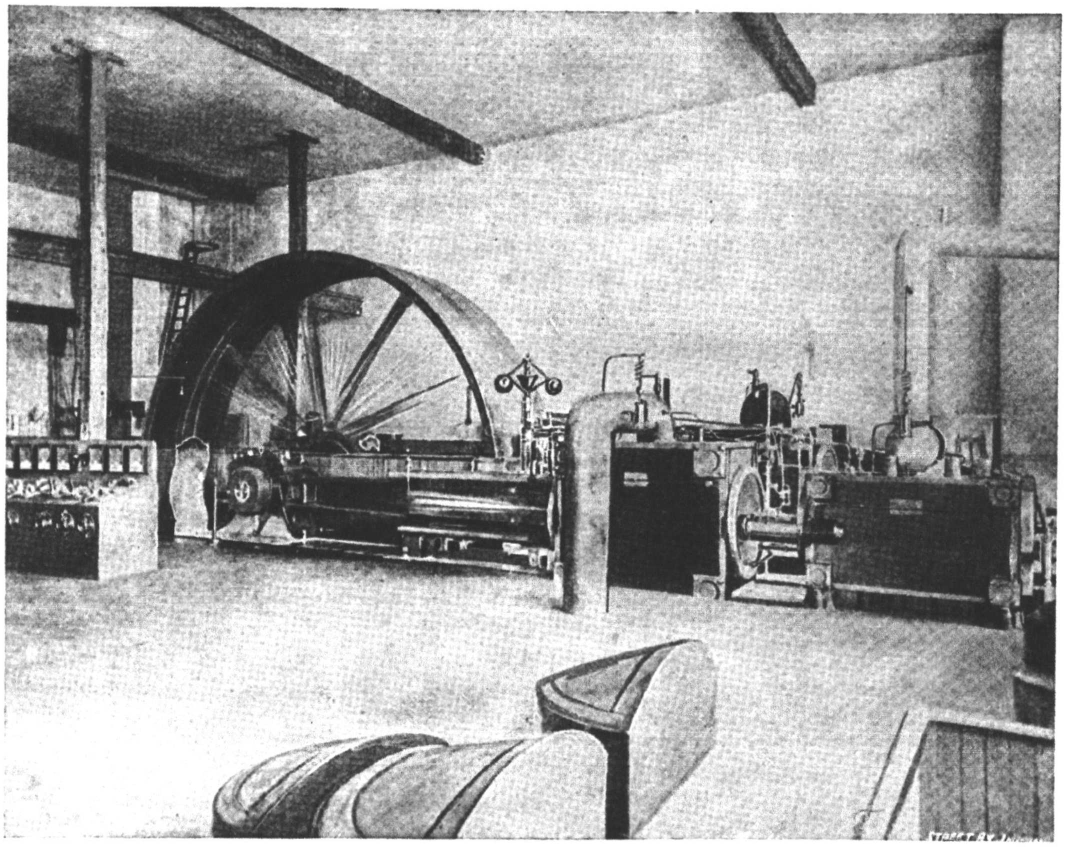


FIG. 8.—INTERIOR OF ENGINE ROOM—MINNEAPOLIS ELECTRIC RAILWAY STATION.

The radii of the single curves are respectively forty feet for the outside, fifty feet the middle and forty-five feet the inside, and unite as shown in sketch. The tracks in car house are ten feet seven inch centres between single curves, and ten feet ten inches between each set. The angles subtended by each curve are as follows: In the forty and fifty feet radius curves the central angles are sixty-one feet while in the forty-five foot radius the central angle is ninety feet. The curves are all made of Johnson girder rail by the Johnson Co., the five and one-half pound section being used for

Digitized by Google

the outer and the seventy-five pound guard for the inner rail.

The entire work consisted of 264 pieces, and the engineer states each piece was plainly and carefully marked, causing no delay whatever in the construction.

The main idea in the study of these curves was to obtain as large a number of tracks as possible in the carhouse, and overcome the great objection of running through a vast number of switches and frogs. By this design turn tables are done away with, and cars are handled without the least difficulty or detention.

The company with commendable enterprise have lighted their entire line to Lake Harriet, a favorite resort a few miles from the business district, with arc lights. The current is furnished by an Excelsior machine situated in the main station.

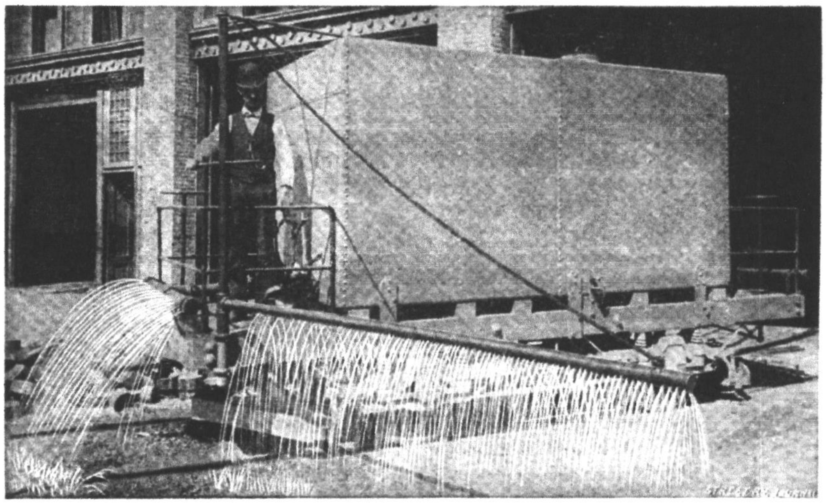


FIG. 10.—SPRINKLING CAR—MINNEAPOLIS STREET RAILWAY.

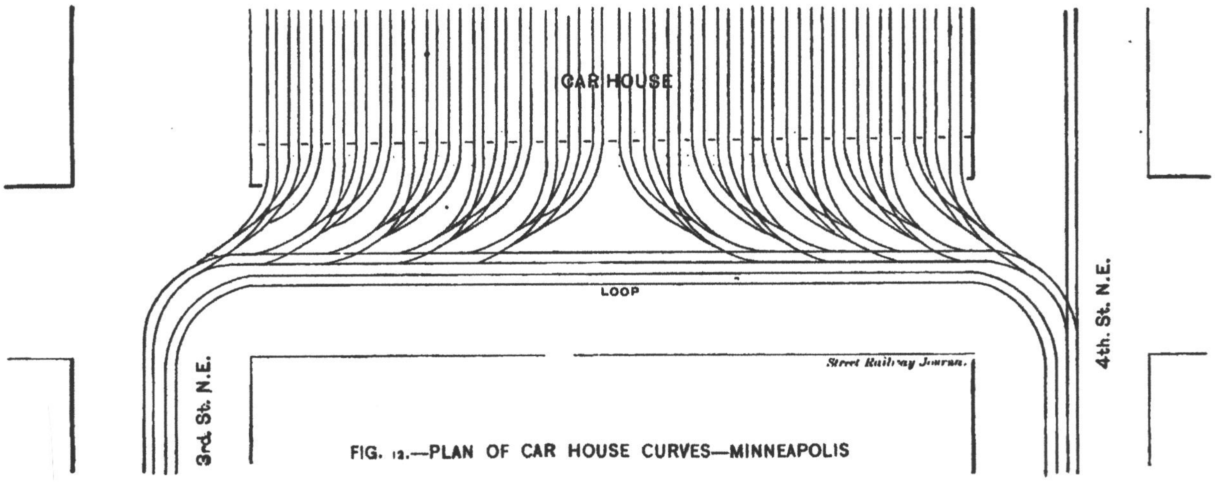


FIG. 12.—PLAN OF CAR HOUSE CURVES—MINNEAPOLIS

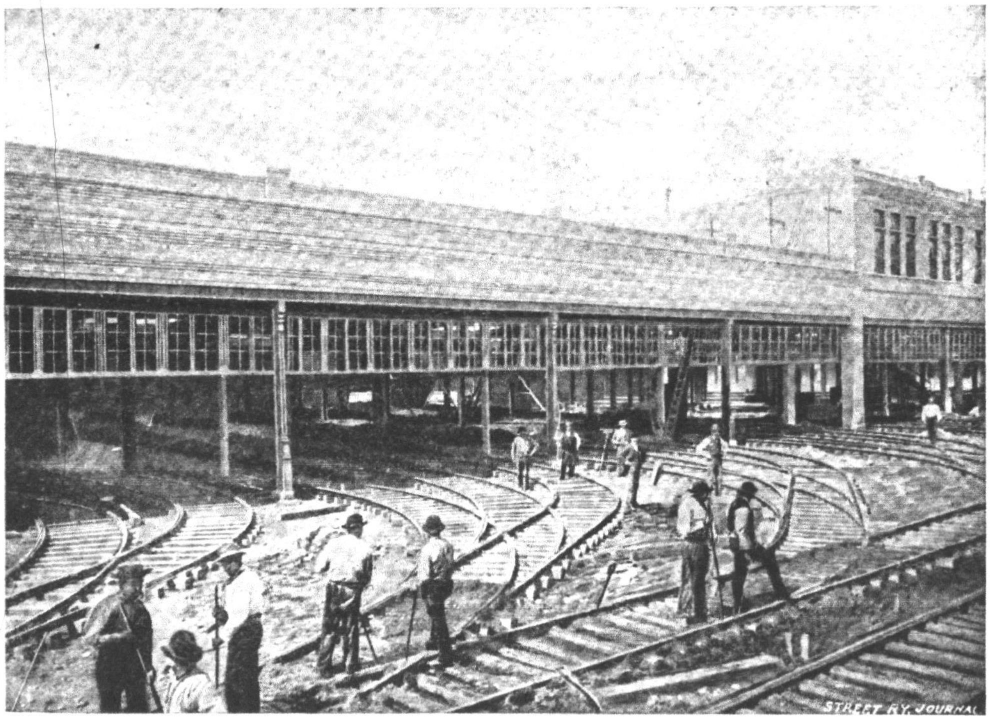


FIG. 11.—VIEW OF CAR HOUSE—MINNEAPOLIS STREET RAILWAY.

Travelling cranes are in use in both stations, facilitating the erection of machinery to a great degree.

Considerable has been done in laying the feeder wires underground in this system, the underground tubes of the Interior Conduit & Insulation Co., of New York, being employed. The length of the tubes at present employed is 400,000 feet, and repeated tests have shown a very high insulation for the entire system.

The belting for the St. Paul plant was furnished by the Chicago Belting Co. of Chicago.

The liberal policy which has characterized the management of the system since its in

Digitized by Google

ception has done much to increase its popularity and profits. Extensions are being made in all directions and the work is progressing as rapidly as possible.

Great credit is due to the efficient management of Mr. Goodrich, and to the engineering department under the direction of Mr. W. F. Carr, for the able manner in which the work of this department has been prosecuted.

Minneapolis Power Station.

Work has been pushed forward during the last few months on the new electric power station of the Minneapolis Street Railway Co. at Thirty-first Street junction and contractors, DeLancey & Cook, have finally finished their work. The original design was to install five engines and five generators, but with the increased demand for street car facilities, it was decided to double the capacity of the power house. This required a remodeling of the original plans. The plant will furnish power to the portion of the street car system which is located south of Washington Avenue and between Minnehaha Falls and Lakes Calhoun and Harriet.

The area of the engine room is 87 × 70 ft. The engines are of the Westinghouse compound type with a high pressure cylinder sixteen inches in diameter, and low pressure cylinder twenty-seven inches in diameter by sixteen inch stroke, and are designed to generate from 250 to 300 H. P. Each is connected to a generator by a twenty-four inch leather belt running around an eighty-two inch pulley on the engine and a thirty-six inch pulley on the generator.

The generators are of the 275 K. W., multipolar type, manufactured by the Thomson-Houston Electric Co. The boiler room is nearly as large as the engine room and contains seven Stirling boilers of 287 H. P. each. These rest upon a solid wall which extends eight feet below the floor, and the whole will be enclosed by brick walls when finished.

The fuel to be used is crude oil which will be pumped in from two tanks as it is needed. The floor of the boiler house will be concrete and supported by arches. The stack is 165 ft. high. The water supply for the plant will be furnished by an artesian well which will be over 1,000 ft. deep.

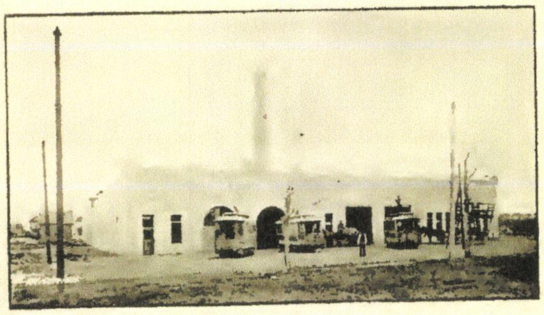
AVERY® POLY VU

5-1892

THE NEW MINNEAPOLIS POWER HOUSE.

Extensive Addition to the Facilities of the Twin Cities Transit System — A Survey of the Methods to be Used.

THE St. Paul-Minneapolis have been heretofore extensively noticed, but it is the habit of these lively twins to continually grow. It is a continued story to tell of their achievements in any one line of improvement. In the matter of rapid transit it has been previous experiences that extended facilities demanded more extension, and as means of travel have grown the traffic has increased. To furnish sufficient power for the large demands that are now made and which will become greater as the summer advances and the numerous conventions that congregate in this vicinity, gather and disperse. A general remodeling of plans long contemplated was deemed necessary by the prophetic souls of the managers and the present extension plant located on Hennepin avenue and bounded by Thirty-first street, Thirty-second street and Blaisdale avenue.



NEW 31ST STREET POWER HOUSE.

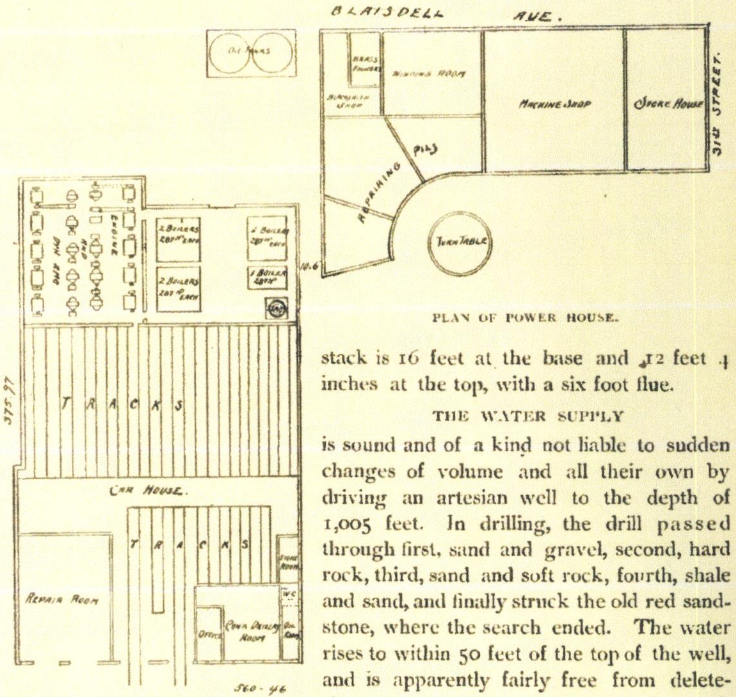
The construction of the building was begun last October, and Contractors De Lancey & Cook brought the matter to a fair conclusion in April.

The original intention was to put in five engines and an equal number of dynamos, but subsequent thought, the settling of the Republican Convention in Minneapolis, and the rapid growth of real estate interests in that vicinity, all brought the determination of the plan of a power house that should be large enough for present use and future exigencies.

This caused a reconsideration of original plans necessary, and resulted in the present proportions of what is phrased, the Thirty-first street power house.

The power house from a front view, as represented in in the first engraving, gives the impression of a building much smaller than it is in reality. Fronting on Hennepin avenue 160 feet and running back to Blaisdell 375 feet. The building covers ¾ of a city block of ground. This area includes the following shops and rooms besides the trackage and spare room necessary: The engine room is 69 feet 7 inches by 86 feet 8 inches inside measurement and 19 feet 6 inches in height. The boiler room is 66 feet by 80 feet and has a 23-foot ceiling. The other rooms, the car house, machine shop, store house, winding room and armature room, are of ample proportions and will be fully equipped with every convenience for storage and repairs.

The structure was planned by Charles Ferrin, who is superintendant of buildings as well, and in building 1,250,000 bricks were used. The boiler room has iron trusses and brick arches while the lighter construction of the engine and dynamo room is supported by wooden beams and heavy posts. The floor of the boiler room is concrete and that of the engine room hard wood. There may be seen in the first engraving the smoke stack which rises 150 feet above the ground. The diameter of the stack is 16 feet at the base and 12 feet 4 inches at the top, with a six foot flue.



PLAN OF POWER HOUSE.

THE WATER SUPPLY

is sound and of a kind not liable to sudden changes of volume and all their own by driving an artesian well to the depth of 1,005 feet. In drilling, the drill passed through first, sand and gravel, second, hard rock, third, sand and soft rock, fourth, shale and sand, and finally struck the old red sandstone, where the search ended. The water rises to within 50 feet of the top of the well, and is apparently fairly free from deleterious elements, although no qualitative analysis has yet been made.

The water will be raised by a 35-foot Cameron mining pump, manufactured by the Cameron Pump Company, of New York City. The advantages of artesian water over the city supply is the regularity of supply and the complete

HENNEPIN AVE.: SHOULD BE NICOLLET AVE.

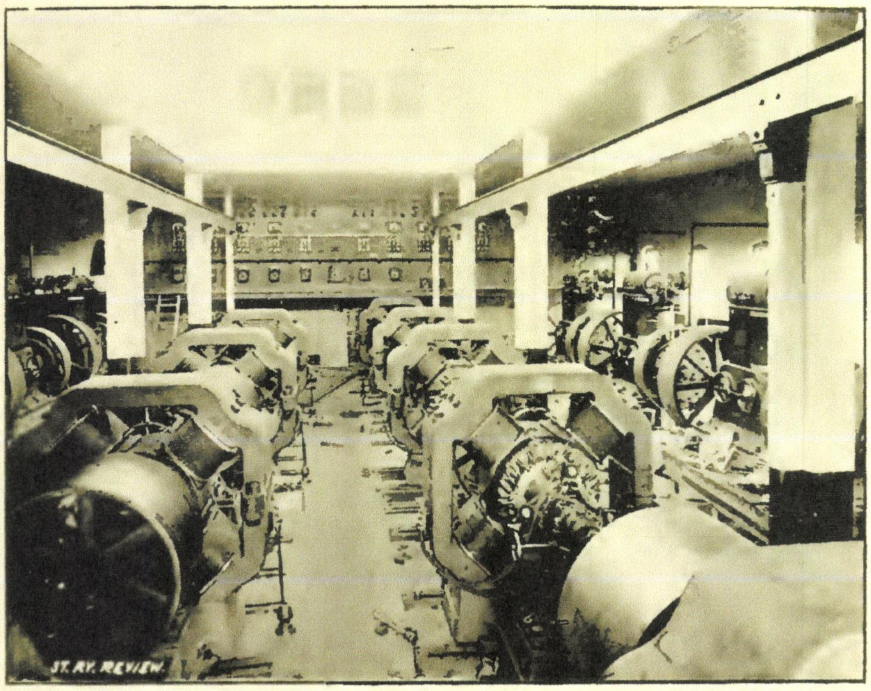
control of the quantity at any time, and economy. The well was driven in 31 days' time.

THE STEAM PLANT

is more than sufficient for the needs at present and fully sufficient for all exigencies that may arise. But, as the territory to which the power is to be transmitted is large, supplying the lines south of Washington Avenue and between Minnehaha Falls and Lakes Calhoun and Harriet, the power will not be wasted nor the equipment inordinately large within a few years.

THE BOILERS

are of the Stirling water tube type, of which but four are shown in the engraving, three reserves being situated on the opposite side of the room.



ENGINES AND GENERATORS.

The boilers are rated at 287 horse-power each, and the feed water is heated to 212 degrees by Wainwright Corrugated Tube Feed water heaters, made by the Wainwright Manufacturing Company, of Boston. No purifier is expected to be necessary.

The piping is a feature worthy of more remark than our space allows. It is probably the largest line in the West. The steam pipes are 18 inches in diameter, and the exhaust pipes 22 inches. Each main is independent, and can be cut off entirely at will. The "header" is 28 inches in diameter, and 43 feet in length. The boilers pipe to this. An independent 18-inch line for each five engines is run from this header to the engine distributing main. Each main has a cut-off valve in the boiler-room so that either entire line from the cut-off valve to the engine can be cut off. At the engine there are cut-off valves between the distributing steam and exhaust main and each engine, so that any particular engine may be cut off entirely from its steam or exhaust connections in case of any exigency that may require it. The entire piping is planned on a basis of 150 pounds steam pressure.

THE ENGINES

are Westinghouse compound, non-condensing, ten in number, and arranged in two batteries of five each, with a rated horse-power of 250 and a maximum of 300 each. The cylinders are 16 inches by 16 inches stroke, and 16 inches by 29 respectively. The crank shaft is 7 inches in diameter, and 11 feet long. The dynamos are belted direct, and the belt wheel is 84 inches in diameter with a 25-inch face.

THE ELECTRICAL SUPPLY.

The direct power for transmission is generated by 10 Thomson-Houston multipolar dynamos, each capable of 275 kilowatts. The maximum will be 550 amperes, at 500 volts, and the minimum 250 with an ordinary load of 200. The coupling mentioned above is direct. The Nott Belting Company, of Minneapolis—a thriving institution in that invigorating atmosphere—made two belts, each 150 feet long and 73 inches wide, requiring 325 hides and weighing 2500 pounds each. This showing, for the belting company so young, is very flattering.

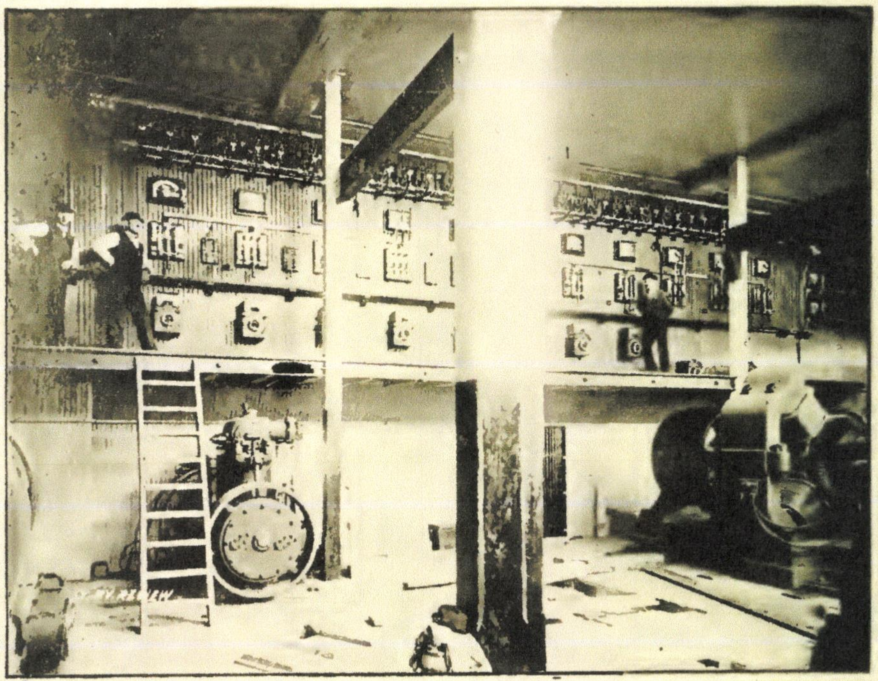
THE SWITCH-BOARD.

That portion of the system operated from the Thirty-first street power-house is divided into 8 sections, each having an independent feeder direct to the power-house, and each feeder supplied with automatic circuit breakers. As will be easily apprehended, the advantage of this arrangement is that of independence, so that if the trolley wire of any section should break, the other 7 would be undisturbed. This practice, it is claimed, originated in Indianapolis. Grounding the return is effected by burying old car wheels, about ¼ of a mile apart, connected with the supplementary wires between the rails.

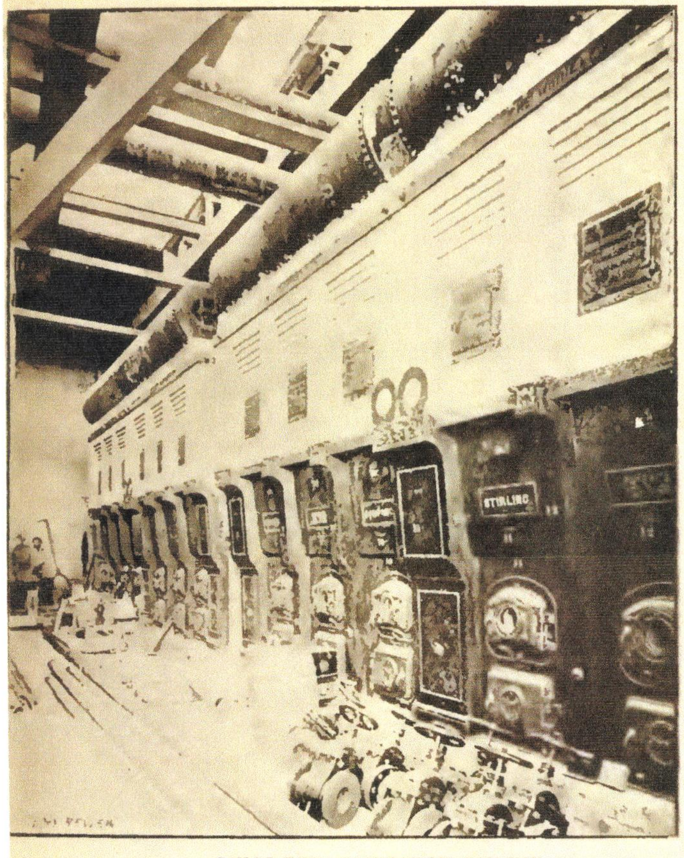
In our engraving of the switchboard, the portion to the right, seen but dimly, is the feeder-board, and that to the left is the switch-board proper.

The system of repairs is so effective that a trolley wire broken at Minnehaha, 6 miles out, is repaired by the linemen at power-house No. in 45 minutes.

A hundred-arc light machine "Excelsior"—Hochhausen system—will be also installed to light the lovely resort, Lake Harriet, which will induce considerably more traffic this year than before.

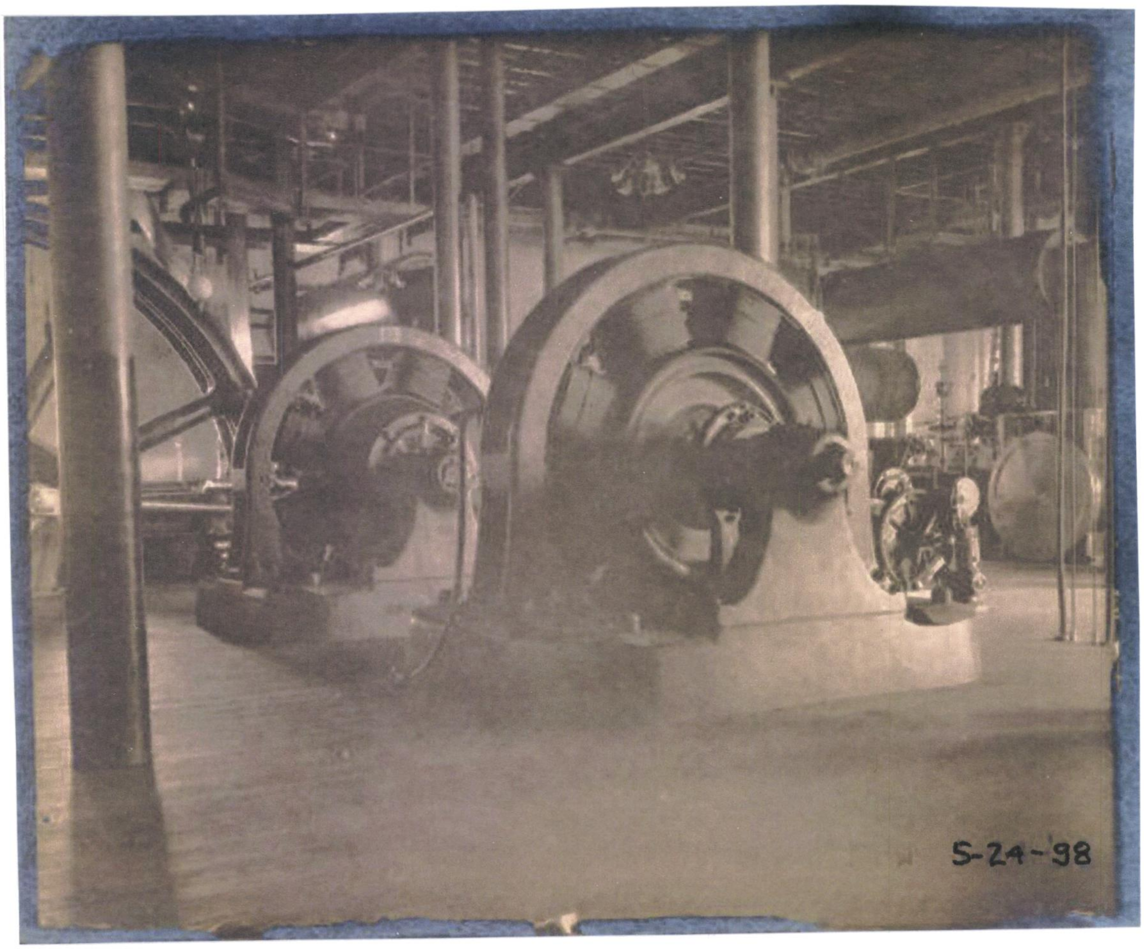


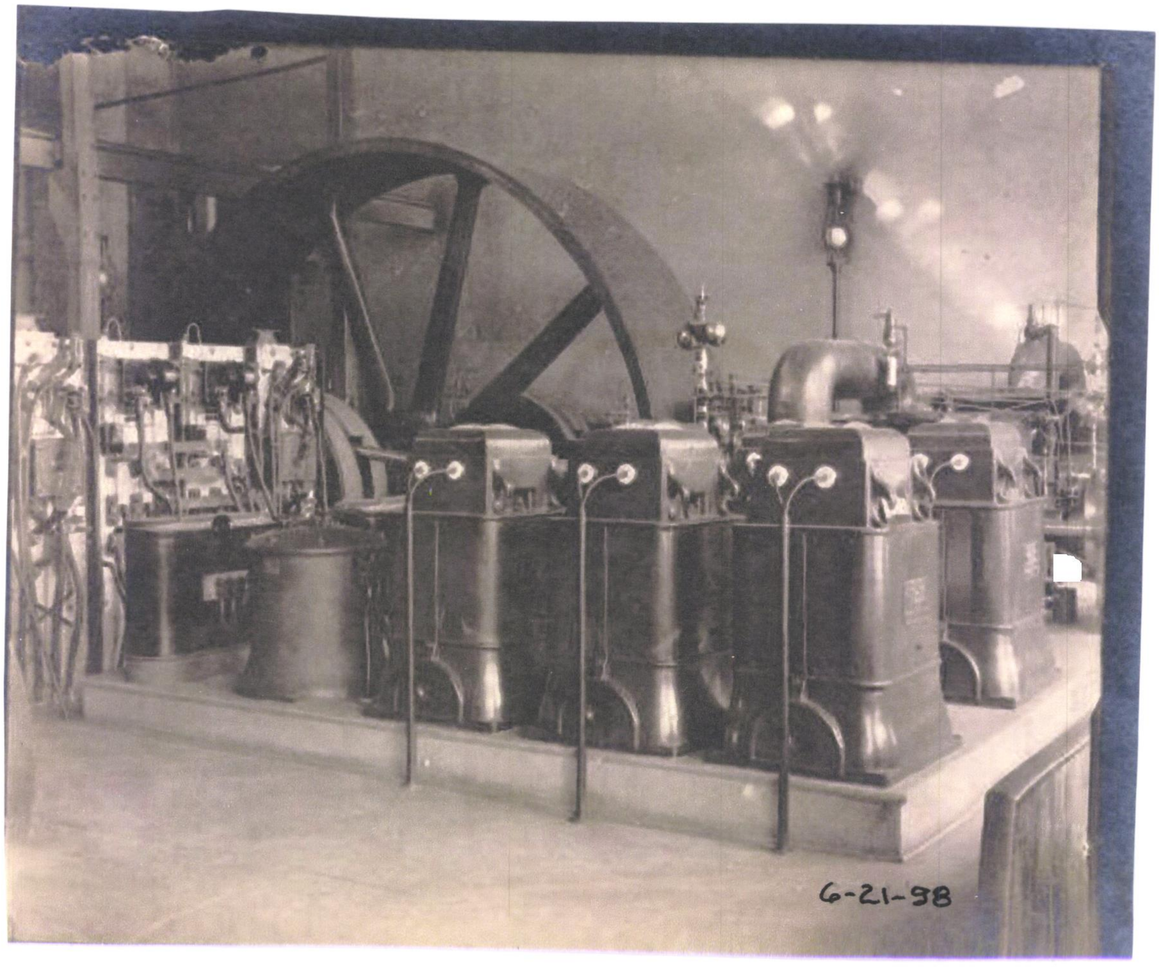
THE SWITCH BOARD.

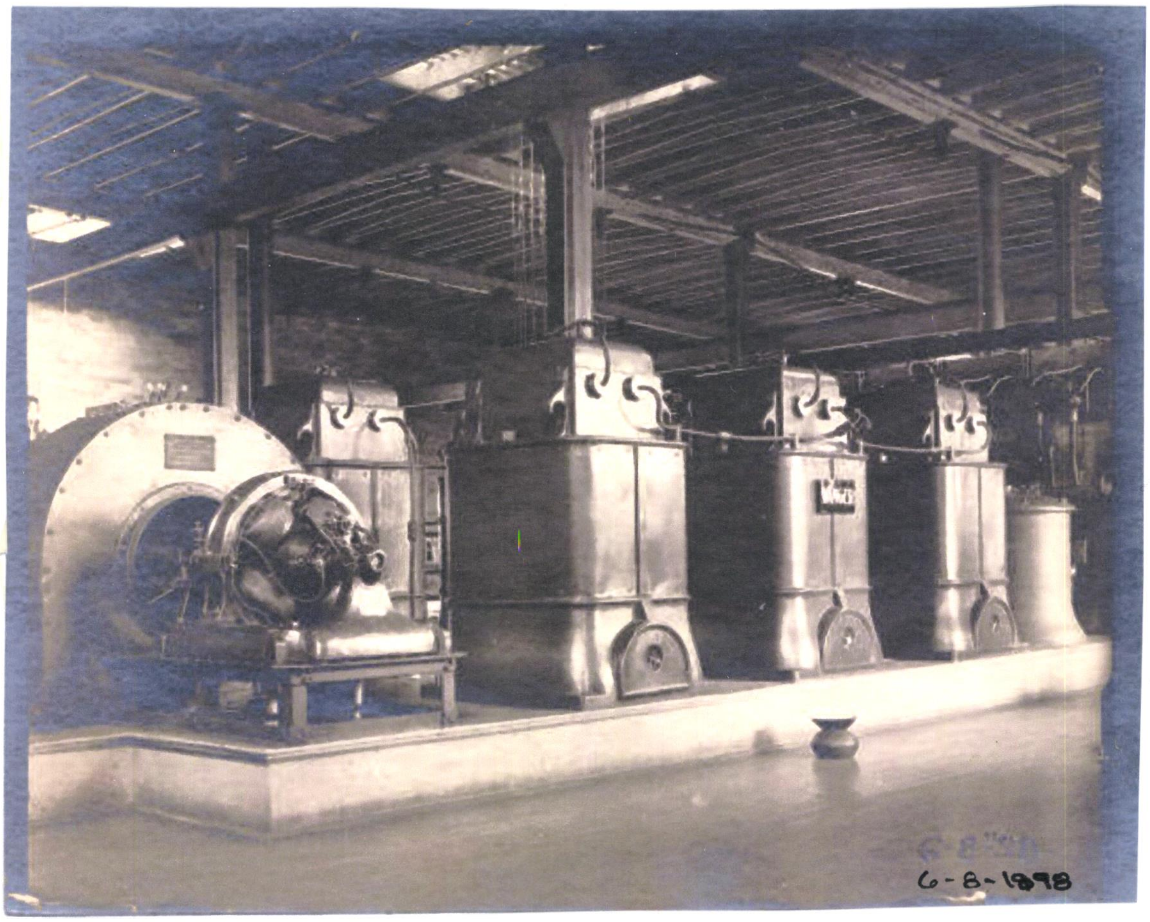


BOILER ROOM MINNEAPOLIS RAILWAY.

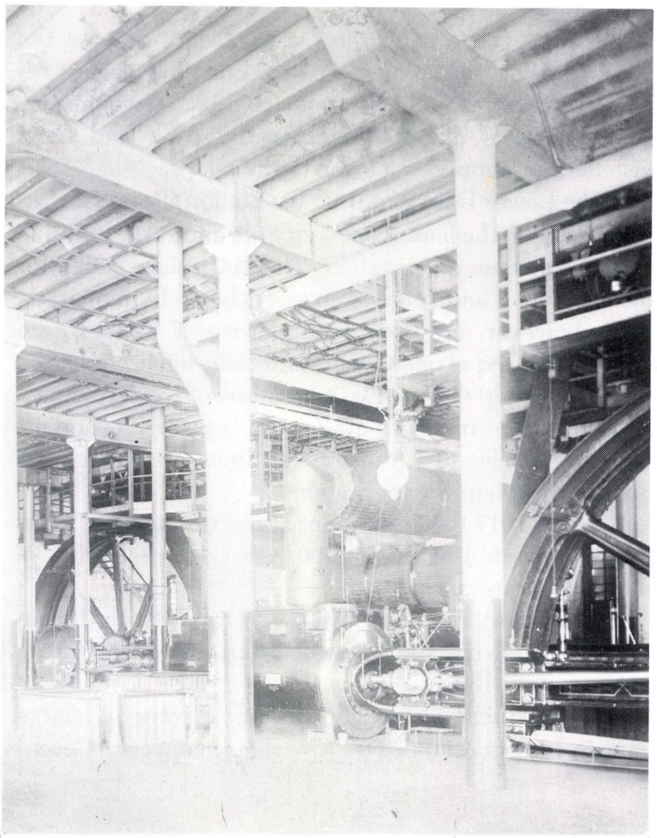
St. Anthony Falls Water
Power Co. collection.
Lower Dam Water Power
Plant construction. BUT
I believe these 3 are
at Main Central Power-
house (steam plant)
3rd ave N. and 2nd St. N.


5-24-98


6-21-98



6-8-1898



Interior view of the Main Central Powerhouse (#1), Minneapolis, about 1901, showing a portion of one of the Corliss engines. (Edmund A. Brush; Robert Bowes collection) ception has done much to increase its popularity and profits. Extensions are being made in all directions and the work is progressing as rapidly as possible.

Great credit is due to the efficient management of Mr. Goodrich, and to the engineering department under the direction of Mr. W. F. Carr, for the able manner in which the work of this department has been prosecuted.

Minneapolis Power Station.

Work has been pushed forward during the last few months on the new electric power station of the Minneapolis Street Railway Co. at Thirty-first Street junction and contractors, DeLancey & Cook, have finally finished their work. The original design was to install five engines and five generators, but with the increased demand for street car facilities, it was decided to double the capacity of the power house. This required a remodeling of the original plans. The plant will furnish power to the portion of the street car system which is located south of Washington Avenue and between Minnehaha Falls and Lakes Calhoun and Harriet.

The area of the engine room is 87 × 70 ft. The engines are of the Westinghouse compound type with a high pressure cylinder sixteen inches in diameter, and low pressure cylinder twenty-seven inches in diameter by sixteen inch stroke, and are designed to generate from 250 to 300 H. P. Each is connected to a generator by a twenty-four inch leather belt running around an eighty-two inch pulley on the engine and a thirty-six inch pulley on the generator.

The generators are of the 275 K. W., multipolar type, manufactured by the Thomson-Houston Electric Co. The boiler room is nearly as large as the engine room and contains seven Stirling boilers of 287 H. P. each. These rest upon a solid wall which extends eight feet below the floor, and the whole will be enclosed by brick walls when finished.

The fuel to be used is crude oil which will be pumped in from two tanks as it is needed. The floor of the boiler house will be concrete and supported by arches. The stack is 165 ft. high. The water supply for the plant will be furnished by an artesian well which will be over 1,000 ft. deep.

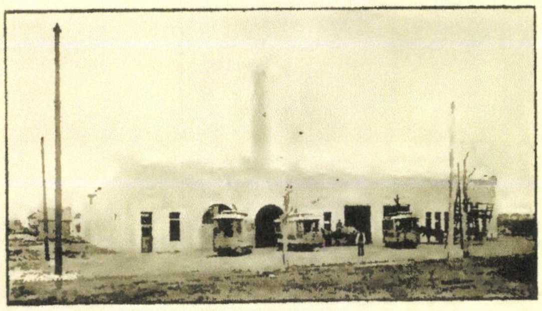
AVERY®
POLY VU

Street Railway Review.

5-1892

THE NEW MINNEAPOLIS POWER HOUSE.

Extensive Addition to the Facilities of the Twin Cities Transit System — A Survey of the Methods to be Used.



NEW 31ST STREET POWER HOUSE.

THE St. Paul-Minneapolis have been heretofore extensively noticed, but it is the habit of these lively twins to continually grow. It is a continued story to tell of their achievements in any one line of improvement. In the matter of rapid transit it has been previous experiences that extended facilities demanded more extension, and as means of travel have grown the traffic has increased. To furnish sufficient power for the large demands that are now made and which will become greater as the summer advances and the numerous conventions that congregate in this vicinity, gather and disperse. A general remodeling of plans long contemplated was deemed necessary by the prophetic souls of the managers and the present extension plant located on Hennepin avenue and bounded by Thirty-first street, Thirty-second street and Blaisdale avenue.

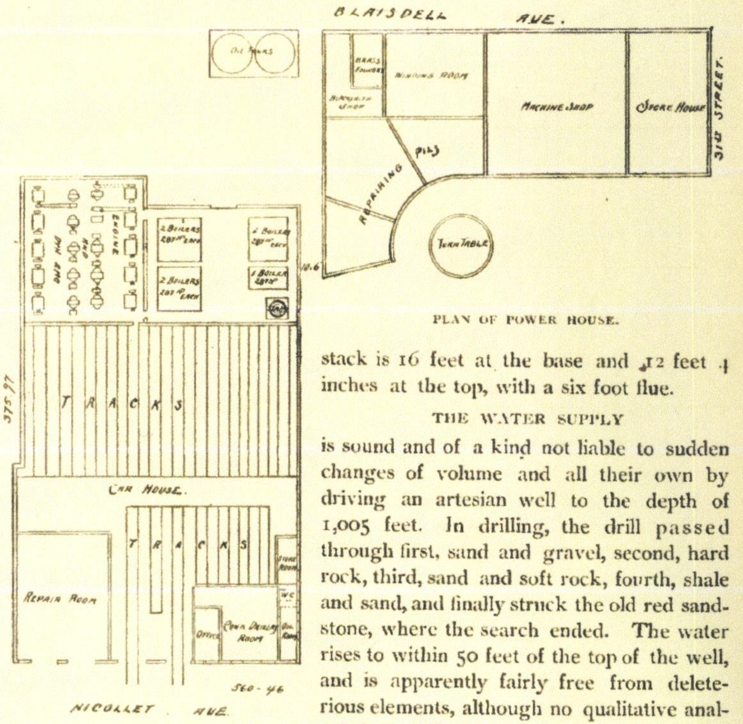
The construction of the building was begun last October, and Contractors De Lancey & Cook brought the matter to a fair conclusion in April.

The original intention was to put in five engines and an equal number of dynamos, but subsequent thought, the settling of the Republican Convention in Minneapolis, and the rapid growth of real estate interests in that vicinity, all brought the determination of the plan of a power house that should be large enough for present use and future exigencies.

This caused a reconsideration of original plans necessary, and resulted in the present proportions of what is phrased, the Thirty-first street power house.

The power house from a front view, as represented in in the first engraving, gives the impression of a building much smaller than it is in reality. Fronting on Hennepin avenue 160 feet and running back to Blaisdell 375 feet. The building covers ¾ of a city block of ground. This area includes the following shops and rooms besides the trackage and spare room necessary: The engine room is 69 feet 7 inches by 86 feet 8 inches inside measurement and 19 feet 6 inches in height. The boiler room is 66 feet by 80 feet and has a 23-foot ceiling. The other rooms, the car house, machine shop, store house, winding room and armature room, are of ample proportions and will be fully equipped with every convenience for storage and repairs.

The structure was planned by Charles Ferrin, who is superintendant of buildings as well, and in building 1,250,000 bricks were used. The boiler room has iron trusses and brick arches while the lighter construction of the engine and dynamo room is supported by wooden beams and heavy posts. The floor of the boiler room is concrete and that of the engine room hard wood. There may be seen in the first engraving the smoke stack which rises 150 feet above the ground. The diameter of the stack is 16 feet at the base and 12 feet 4 inches at the top, with a six foot flue.



PLAN OF POWER HOUSE.

THE WATER SUPPLY

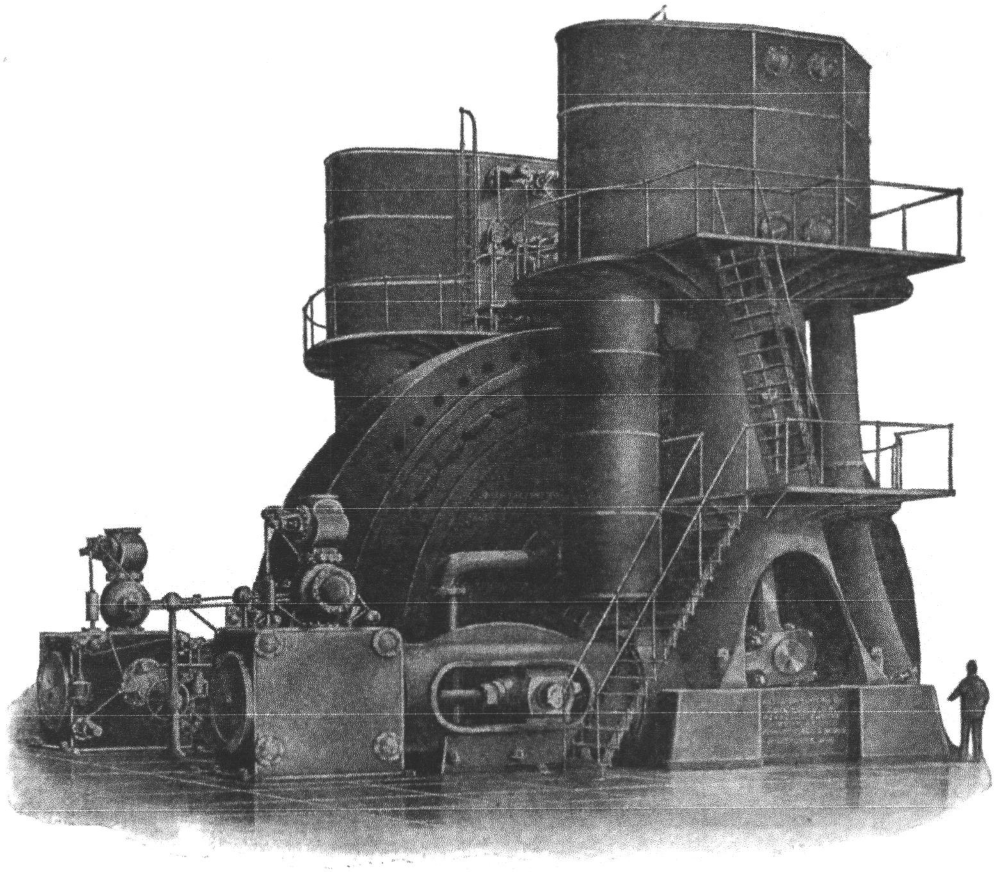
is sound and of a kind not liable to sudden changes of volume and all their own by driving an artesian well to the depth of 1,005 feet. In drilling, the drill passed through first, sand and gravel, second, hard rock, third, sand and soft rock, fourth, shale and sand, and finally struck the old red sandstone, where the search ended. The water rises to within 50 feet of the top of the well, and is apparently fairly free from deleterious elements, although no qualitative analysis has yet been made.

The water will be raised by a 35-foot Cameron mining pump, manufactured by the Cameron Pump Company, of New York City. The advantages of artesian water over the city supply is the regularity of supply and the complete

HENNEPIN AVE.: SHOULD BE NICOLLET AVE.

Allis-Chalmers Co.
CHICAGO

SOLE BUILDERS OF
Reynolds-Corliss Engines
FOR ALL POWER PURPOSES



Street Railway and Electric Light Engines
A SPECIALTY

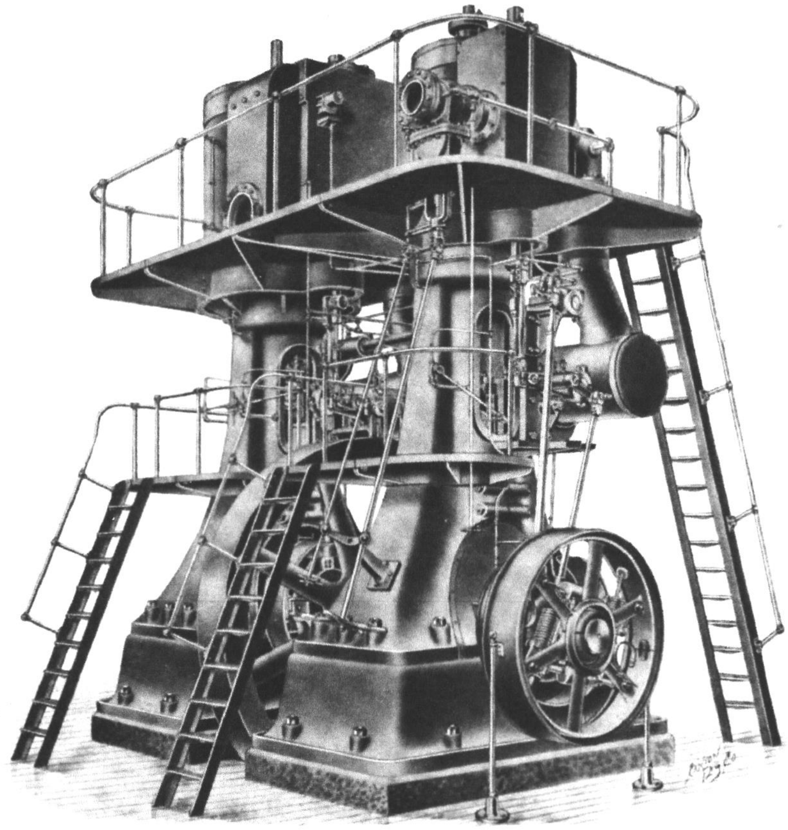
BULLOCK
Electrical Apparatus
for all purposes.

Digitized by Google

OCT 1904

The Buckeye Engine

Has no Superior in Economy, Regulation and Durability



Horizontal, Vertical, Horizontal-Vertical. Simple, Tandem and Cross Compounds. Condensin
Condensing. Low, Medium and High Speeds.
In Horse Powers from 20 to 8,000. Especially Adapted for Electric Railway Work.
The Largest Line of Modern Engine Patterns in the World.

SEE OUR EXHIBIT

Machinery Building, Block 45, Aisles G and 9
Louisiana Purchase Exposition

BUCKEYE ENGINE CO., 100 FRANKLIN STREET, SALEM, O., U.

WATCH THIS SPACE FOR NEW ILLUSTRATIONS

Minneapolis Tribune (1867-1908); Dec 28, 1902;
ProQuest Historical Newspapers Minneapolis Tribune (1867-1922)
pg. 5

MITE OF A BOY STARTS ENGINE

Mammoth New Machine, Installed by Street Railway Company, Is Ready.

RUNS VERY SMOOTHLY

Little Son of Mr. and Mrs. R. C. Taylor Turns on Steam for Testing Its Capabilities.

When Robert Wright Ogilbie Taylor, the little son of Mr. and Mrs. Robert C. Taylor, yesterday turned on the steam which officially started the Twin City Rapid Transit company's new tandem compound 1,500 horse power engine for the first time, it was a signal for the mechanical employes to take a long breath. The company has been having trouble all winter with the lack of power caused by the low water in the river.

The starting of the new engine marks the advent of a safeguard against all fluctuations in the depth of the current in the Mississippi. For when there is not enough power in the water to operate the three big generators at the Third avenu power house the new engines can be set to work on the generators in a moment and the delays to which the public have been subject in the early morning and evening hours will be done away with.

The new engine worked perfectly on its first trial under the general supervision of Chief Engineer Taylor and the direct supervision of John E. Meeken and H. F. Bady. The big ponderous mass of machinery weighing hundreds of tons, and requiring so much power to start it, moved with hardly a sound when it was once set in motion.

The Buckeye engine was intended originally for the Russian government, but when it was completed the Russian authorities were not quite ready to receive it and Chief Engineer Taylor stepped in and purchased it. It is the largest engine of its kind in the world.

Robert C. Taylor, chief engineer and master mechanic of the Twin City Rapid Transit company, was happily surprised last night with a gift from his employes in the form of a Waltham non-magnetic gold watch, with a gold chain and charm in which had been put a picture of his youngest boy.

The presentation was made in the new engine room of the Third avenue power house in front of the newly installed Buckeye engine. R. L. Costigan, general purchasing agent of the company, in presenting the gift said that it was a token of regard and esteem from the men over whom he ruled so well and yet so kindly, and with the gift went the hopes of the men that he would meet with large success in his new position.

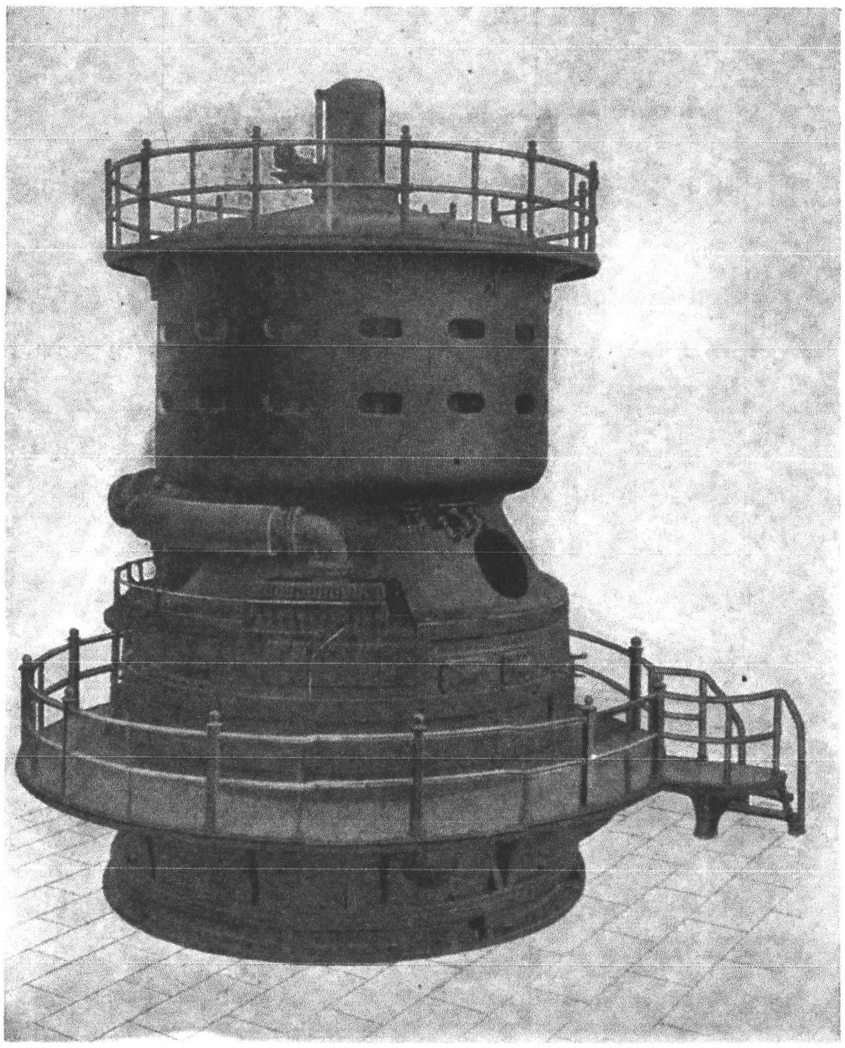
Mr. Taylor was deeply moved by the gift and thanked the men with a good deal of feeling.

Mr. Taylor will leave Minneapolis Jan. 1 to begin his labors as the chief engineer of the Brooklyn Rapid Transit company at a salary of $5,000 a year.

Digitized by

General Electric Company

CURTIS STEAM TURBINES



5000 KW. CURTIS STEAM TURBINE DIRECT CONNECTED TO 5000 KW. ALTERNATING CURRENT GENERATOR

Curtis Steam Turbines are built in capacities from 1½ KW. to 500 KW. direct current units and 500 KW. to 5000 KW. alternating current units

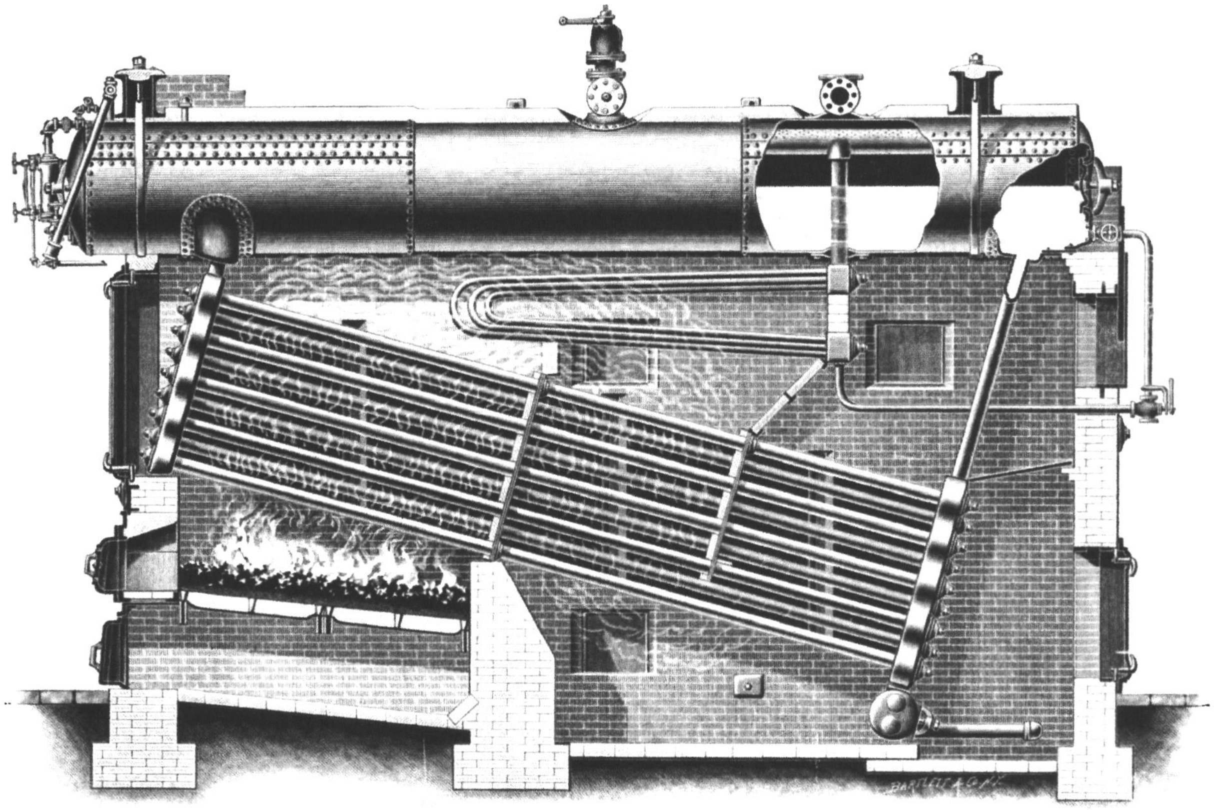
PRINCIPAL OFFICES SCHENECTADY, N. Y.

SALES OFFICES IN ALL
LARGE CITIES

NEW YORK OFFICE, 44 Broad Street
LONDON OFFICE, 83 Cannon Street

OCT 1904

Water Tube Boilers



All Wrought Steel Babcock & Wilcox Boiler Built for 200 lbs. Steam Pressure and Fitted with Patent Superheater.

The Babcock & Wilcox Co.

85 Liberty St., New York, N. Y., U.S.A.

...BRANCH OFFICES...

BOSTON, 219 John Hancock Bldg.
PHILADELPHIA, 1110-1112 No. American Bldg.
SAN FRANCISCO, 63 First Street
PITTSBURG, 1218 Frick Bldg.
CHICAGO, 1215 Marquette Bldg.
CLEVELAND, 706 New England Bldg.
ATLANTA, Empire Bldg.
NEW ORLEANS, 339 Carondelet Street
MEXICO CITY, 7 Avenida Juarez
HAVANA, CUBA, 116½ Calle de Habana

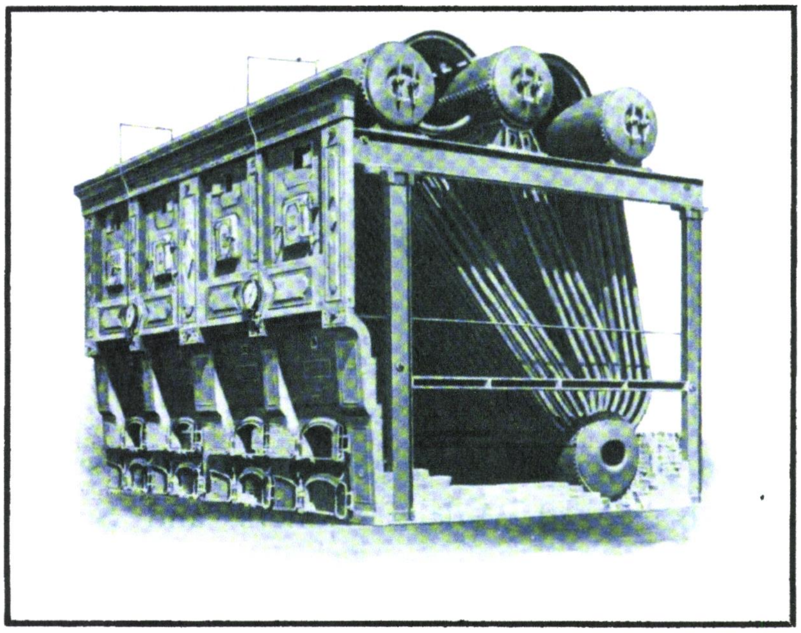
Digitized by Google

OCT 1904

THE STIRLING BOILER

2,000,000 HORSE POWER IN USE

The only boiler made which combines extreme simplicity with every essential of safety, efficiency and durability



No Cast Pressure Parts **No Caps or Gaskets**
Wrought Steel Throughout

The removal of FOUR manhole covers gives access to the entire interior, exposing every rivet, joint and tube in the boiler. Cleaned in one-fourth the time required by other types

THE STIRLING COMPANY

General Offices:
Pullman Building, CHICAGO, U. S. A.

New York Philadelphia Pittsburg San Francisco New Orleans Cincinnati
Boston Buffalo Toledo Atlanta Washington
53 Victoria St., London, S. W. 53 Deansgate Arcade, Manchester, England
Yokohama Buenos Ayres Honolulu Johannesburg
WORKS: BARBERTON, OHIO

Digitized by Google

COST OF 3D AVE. NORTH & 2D ST. POWER PLANT
BUILDING EQUIPMENT, ETC.
(From Construction Books)

- 1901 - 1902 - 1903 -

BUILDING		
This includes alterations and additions to building, not original cost of building		
Fire Wall	3,730.00	
Contract & Misc. Material	12,270.25	
Alterations & Additions	397.08	
Account Congdon Contract	1,363.14	
Necessary Work to equip building for steam plant (0.8302)	2,971.50	
Necessary Work Account of Temporary Steam plant (.8303)	412.27	
Account Temporary Steam plant	3,515.00	
Arrange Section of Building for Storage batteries	1,192.14	25,851.38
STEAM EQUIPMENT		
Engines account Temporary Construction	38,905.60	
Boilers, Stokers, Heaters, etc.	68,227.95	
Necessary work to equip plant	8,995.60	
Misc.	1.50	
Drayage	26.11	
Frt. on parts, Buckeye Engine	70.84	116,227.60
STORAGE BATTERIES		
Expenses of E. H. Scofield	139.00	
" from Gen'l Books	95.50	
Storage Batteries	80,000.00	
Cables, etc.	557.23	80,791.73
MISCELLANEOUS		
1/2 Cost of Miscellaneous Items in Books (Bal. to 10th & St. Peter)		4,167.78
		227,038.49
CREDIT		
In 1909 two engines traded to Allis Chalmers Co. for air brake equipment at		8,000.00
		219,038.49

(Note: There were charges in "Power Plant" suspense A/c of $6,944.21, for removing machinery from 3d Ave. power house and the Hill St. power house, none of which is included in above.)

6-[illegible]5

Building & Lots 6, 7. 8, & Part of 5 in
Bk 33. TOWN OF MPLS SOLD IN 1908
TO W. B. JORDAN, ET AL. 80,000.00
LESS COMMISSION a/c SALE 5,000.00
75,000.00

CONSTRUCTION

The St. Anthony Falls Electric Transmission Plant.

The installation of the new plant for utilizing the water power of St. Anthony Falls, at Minneapolis, is rapidly nearing completion. The plant is the property of the St. Anthony Falls Power Company, but the entire output has been leased for a period of forty years to the Twin City Rapid Transit Company. Under this name the Minneapolis Street Railway Company, the Minneapolis, Lyndale & Minnetonka Railway Company and the St. Paul City Railway Company are consolidated. This company operates all the street railways of Minneapolis and St. Paul, a total of about 225 miles, accommodating a population of nearly 400,000 people. With the exception of 6 miles of cable road, all the lines are equipped with electricity, the power being furnished from three power houses whose combined capacity is 5000 h. p. As soon as the new plant is in running order the old power houses will be shut down, but will be kept in readiness for use in case of a breakdown at the larger station.

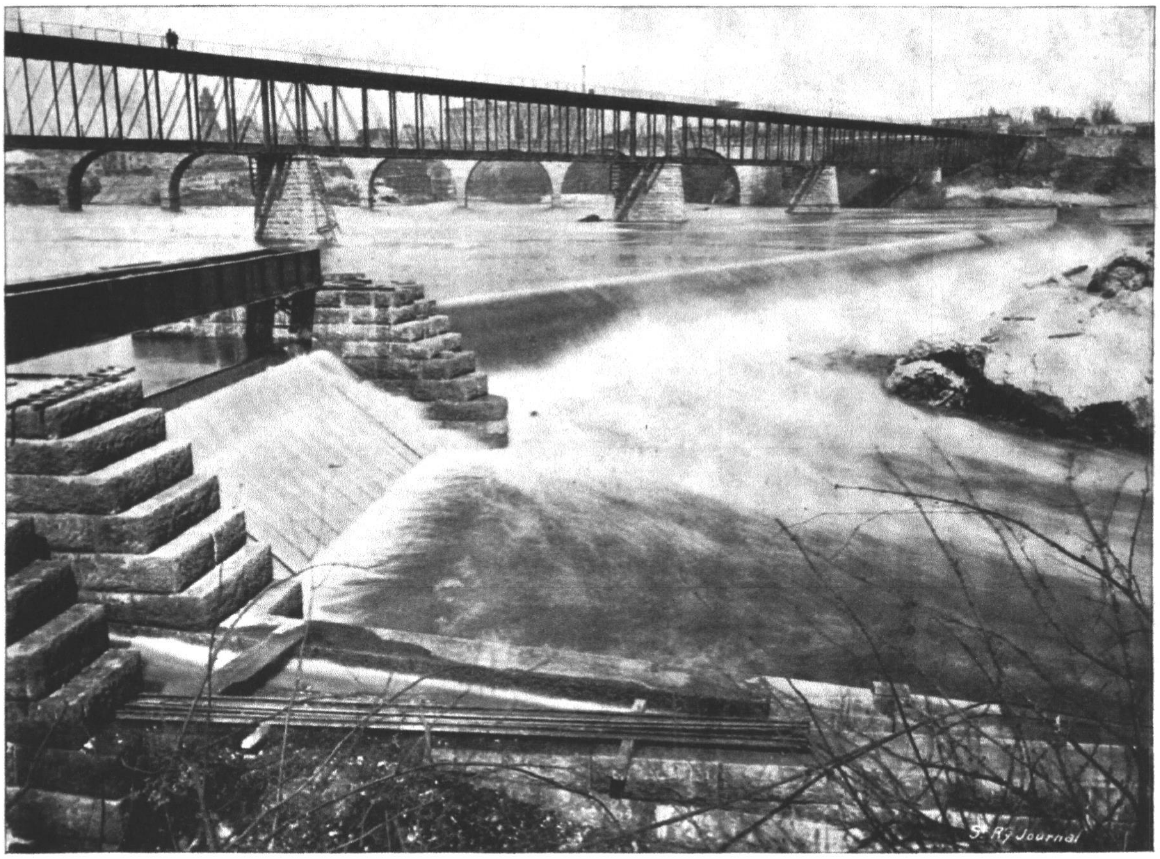


FIG. 1.—HIGH WATER OF MAR. 31, 1897, AT PLANT OF THE ST. ANTHONY FALLS POWER CO.

While the two cities are ordinarily stated as being 10 miles apart, the intervening space is building up so rapidly as to already make practically one city. The St. Anthony Falls are very nearly the center of population of the two and a more economical location for a power house with respect to the cost of feeders could not have been chosen.

The dam for securing the necessary head is thrown diagonally across the river several hundred feet below the Tenth Avenue bridge in the city of Minneapolis and a quarter of a mile or more below the large dam which supplies power to the milling district. In plan it is in the shape of an inverted V with the apex up stream, as will be seen from Fig. 6. Beginning on the west side of the river a log sluice is located next the bank for passing the logs of lumbermen down stream. Next is a bear trap to be noted later. After this comes the first section of the dam proper which is 366 ft. long, 13 ft. above the bed of the river and extending 16 ft. below the river bed. The dam throughout is of solid masonry construction, the coping and down stream face being of granite, and the remainder of blue limestone brought from the company's quarries only a short distance away. The upstream face of the dam as originally built was almost perpendicular, but this is to be supplemented by stone filled crib work and an inclined timber floor for passing logs and ice over the dam during high water. The downstream face is in a series of steps over which the water falls until it strikes an apron 15 ft. wide, of railway iron laid in concrete and securely anchored.

The second section of the dam extending diagonally down stream from the apex of the V forms one side of the head race. It is 444 ft. long, 14 ft. above the river bed and of the same general construction as section one, but with a steel coping. Between this section and the last, which is only 50 ft. long and 12½ ft. above the river bed, are two more bear traps similar to the one on the west side. Between the last section and the turbine chambers is another log sluice for passing out what logs get into the head race.

The three bear trap gates mentioned above are for the purpose of controlling the head of water on the turbines. They are each 50 ft. in width, of steel construction decked with wood and move between solid masonry piers 8 ft. wide, 40 ft. long and 25 ft. high. The dressed surfaces of the piers against which these gates move is clearly shown in Fig. 2. The gates will be operated by hydraulic pressure.

The head race is approximately 207 ft. wide and 600 ft. long. The second and third sections of the dam form one side and the east bank of the river the other. A head of 20 ft. will be maintained on the turbines. While the flow of the river during the recent high water reached 60,000 cu. ft. per second, the minimum flow is but 2000 cu. ft. per second, corresponding to 4000 minimum h. p. The average flow of the Mississippi at Minneapolis is, however, 6000 cu. ft. To prevent rubbish and ice floating in the river from reaching the wheels, a substantial steel rack frame extends the full width of the race. To prevent the clogging of the rack an automatic rack cleaner will be installed; this will travel the full length of the rack and be operated by an electric motor directly attached to the machine. The material gathered by this machine will be deposited on a belt conveyor and discharged into a sluice which will carry it into the tail race.

The power house situated as shown in the illustrations is 250 ft. long, 57 ft. wide, without the turbine chambers which are 40 ft. wide, extending nearly the full length of the power house. The building is of fireproof construction, the framework and roof trusses being of steel furnished by the Gillette-Herzog Manufacturing Company. The walls are of hollow, salt glazed tile 16 ins. thick, made by the Pioneer Fireproof Construction Company. The roof is of book tile, covered with cement and finished with roofing slate, and having a galvanized iron cornice. The height of the main walls is 35 ft., and to the peak of the roof is 51 ft.

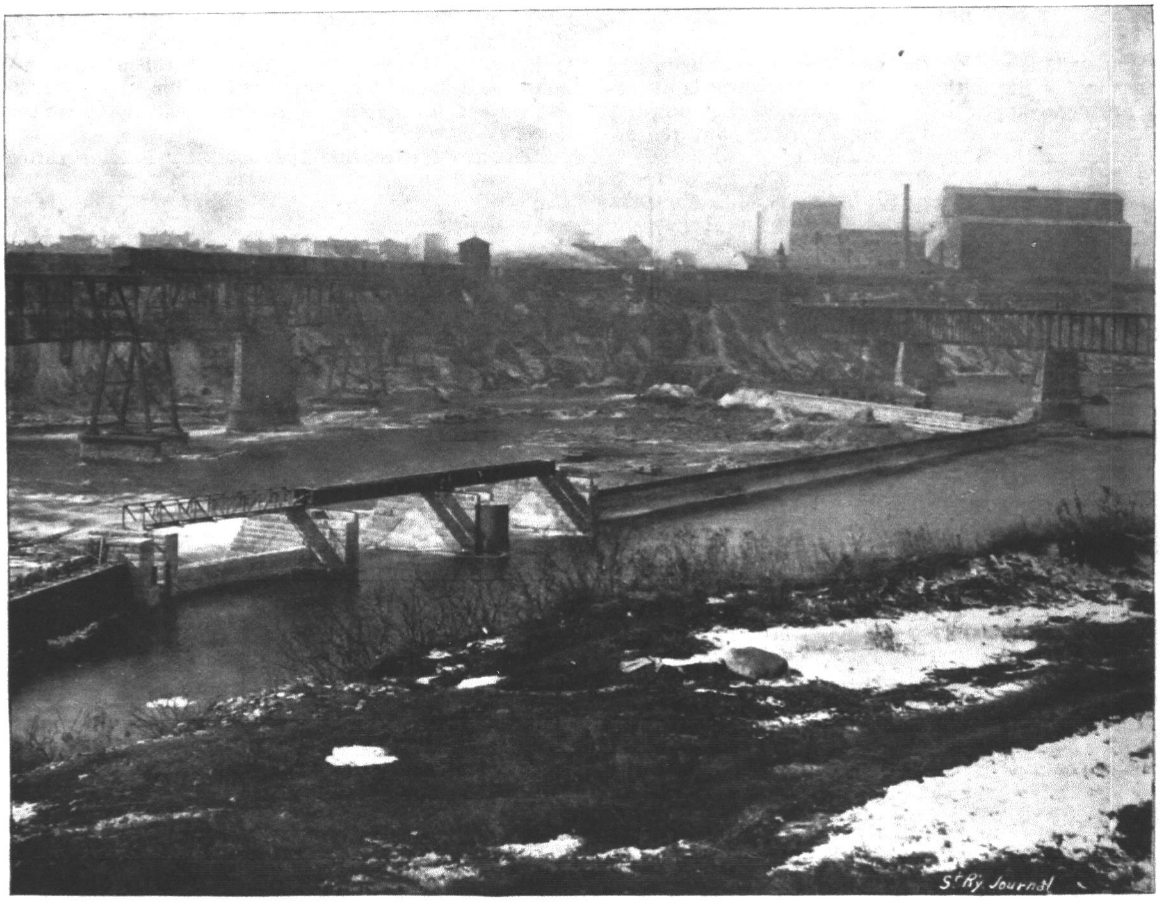


FIG. 2.—VIEW OF DAM AND RIVER FROM EAST BANK

The interior of the power house will be tastefully finished in hard wood; it is lighted by fifteen windows, 12 ft. × 25 ft. The switchboard gallery is lighted by ten windows, 4 ft. × 7 ft. The building will be heated by electricity; for this purpose it is estimated that 1000 h. p. per day will be required during the winter season.

A 20 ton traveling crane runs the entire length of the building and is operated by hand from a gallery attached to the bridge.

The capacity of the plant is 10,000 h. p. in ten units of 1000 h. p. each. Each unit consists of one 1000 h. p. General Electric generator direct connected to a horizontal shaft on which are four Victor turbines of 250 h. p.

Digitized by Google

each, 42 ins. in diameter and running at 130 r. p. m. These turbines are manufactured by the Stilwell-Bierce & Smith-Vaile Company. The ten turbine chambers are of solid and massive masonry with partition walls 4 ft. thick; the head walls separating the water from the main room of the power house are 7 ft. 6 ins. thick, of heavy limestone masonry. In these walls are set the flume head thimbles each 8 ft. in diameter, closed with heavy cast iron covers bolted to the masonry and which carry the stuffing boxes through which the wheel shafts pass to be coupled to the generator.

There are two head gates each 8 ft. wide and 9 ft. high, which admit water to each turbine chamber. These gates will be operated by a simple hoisting attachment on the roof of the turbine chamber. Each chamber has a separate and independent tail race, as wide as the chamber and 100 ft. long. This passes under the power house and discharges into the tail race below.

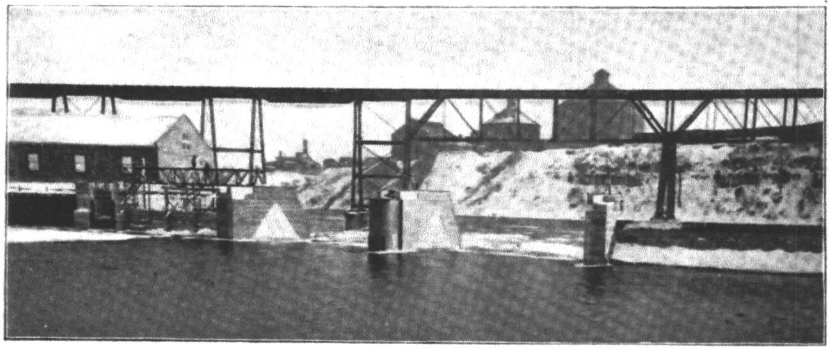


FIG. 3.—HIGH WATER MAR. 1, 1897.

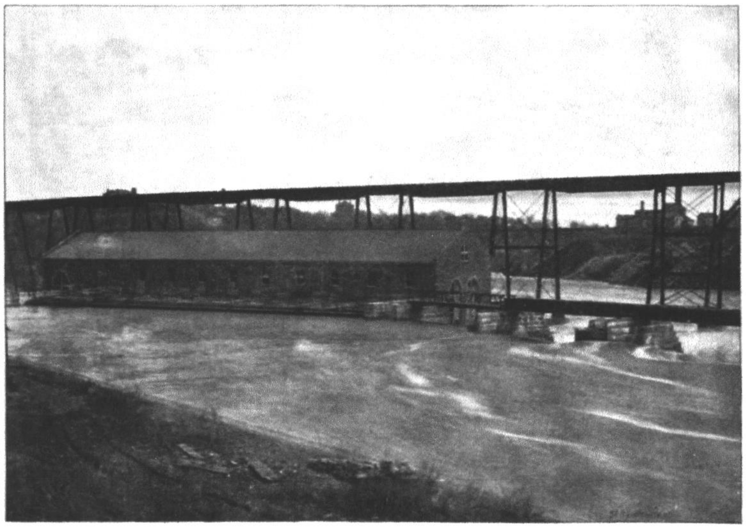


FIG. 4.—VIEW OF POWER STATION DURING HIGH WATER OF MAR. 31, 1897.

The tail race, power house, and turbine chambers stand on a sub-foundation of concrete 2 ft. thick and 220 ft. square. In the eastern end of the power house are installed two 150 h. p. turbines to be direct connected to two exciters.

The speed regulation of the entire plant is effected by type B governors (see Fig. 7) made by the Lombard Water Wheel Governor Company. These governors are of the latest and most approved design, and are guaranteed to hold the normal speed of the plant constant, and to hold the momentary fluctuations of speed, due to large load variations, within 5 per cent from normal, under any conditions of load variation.

Those who are already familiar with the type C governor made by this company will note that there are two auxiliary cylinders on this type B governor, making in all three cylinders. The uppermost is controlled by the centrifugal balls; this actuates the middle cylinder which is in itself a large piston valve, which latter actuates the lowest cylinder which moves the water wheel gates. This type of governor gives the promptest and most powerful gate movement ensuring the closest possible speed regulation of the whole plant under the most trying conditions of load variation.

The power house is designed with a view to placing a 1000 h. p. steam engine by the side of each generator to which it may be coupled in the event of low water or injury to the turbines.

The complete electrical equipment was furnished by the General Electric Company through its representative, A. S. Huey. It is proposed to distribute current at three voltages; direct current at 600 volts for the lines in the immediate neighborhood of station, and alternating current at 3450 volts for short transmission and at 12,000 volts for long transmsision.

The immediate equipment of alternators will include five of the 700 k. w., three phase, revolving armature type. These machines will be equipped with thirty-two poles, will operate at an e. m. f. of 3450 volts and a speed of 130 r. p.

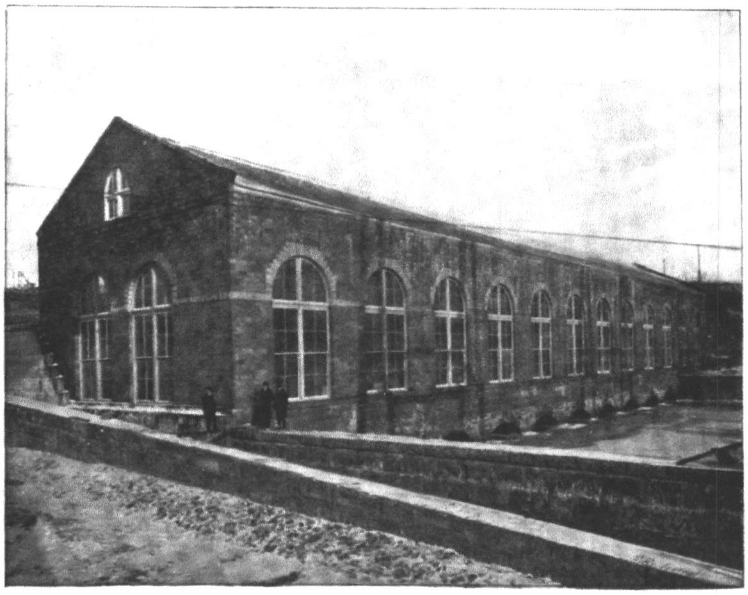


FIG. 5.—VIEW OF POWER STATION, SHOWING OPENING INTO TAIL RACE AND SLUICEWAY FOR LOGS IN FOREGROUND.

Digitized by Google

m. They are designed to be directly connected to the water wheels, and the shaft extends on both ends so as to receive the coupling for the water wheel and steam engine. The weight of the revolving part is about 25,000 lbs., and that of the complete machine 84,000 lbs.

The direct current equipment will consist of two M. P. 8-700 k. w., 600 volt railway generators, to operate at 130 r. p. m. The machines will be of the standard construction, and designed to be directly connected to the water wheel. As with the alternators, the shafts extend on both ends, for the purpose of receiving the coupling of the water wheel or steam engine. The approximate weight of the revolving part is 34,000 lbs., and that of the complete machine, 110,000 lbs. The three phase generators will be excited by means of two M. P. 6-100-280-600 volt continuous generators of standard construction.

There will be six step-up transformers, each 233 k.w., making a total of 1400 k. w. capacity, of the air blast type. The primary voltage of these transformers will be 3450, and the secondary voltage 12,000, which will be the e. m. f. of the line to St. Paul, a distance of 10 miles. The transformer ventilating device will consist of a 50 in. blower, coupled direct to the four pole motor.

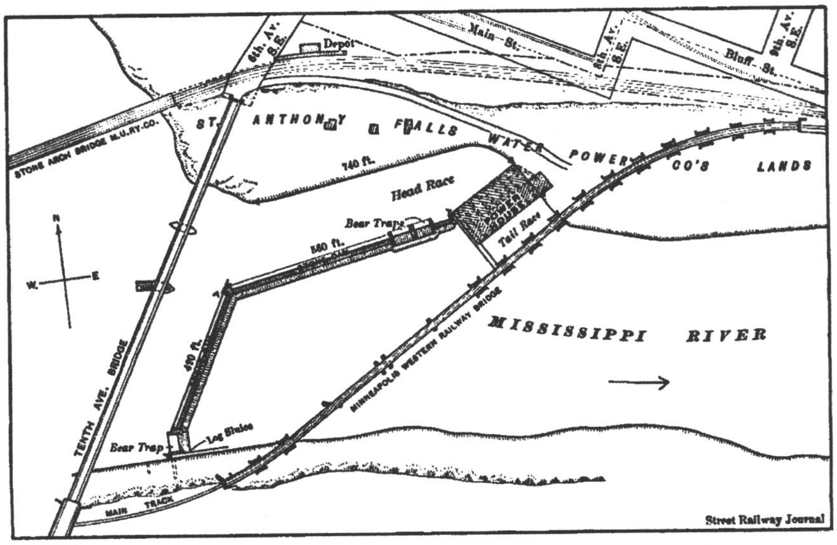


FIG. 6.—PLAN OF PLANT OF ST. ANTHONY WATER POWER CO.

There will be three substations—two in Minneapolis and one in St. Paul. At station No. 1 there will be installed two 600 k. w. rotary converters, giving a 580 volt direct current. At station No. 2 there will be one 600 k. w. rotary converter, and at station No. 3, which is located at St. Paul, there will be two 600 k. w. rotary converters. At the substations will be, of course, all necessary step-down transformers, marble switchboards and controlling apparatus, making the plant most complete in every respect. The rotaries will run in parallel with the street railway company's present generators, which are at present operated by steam.

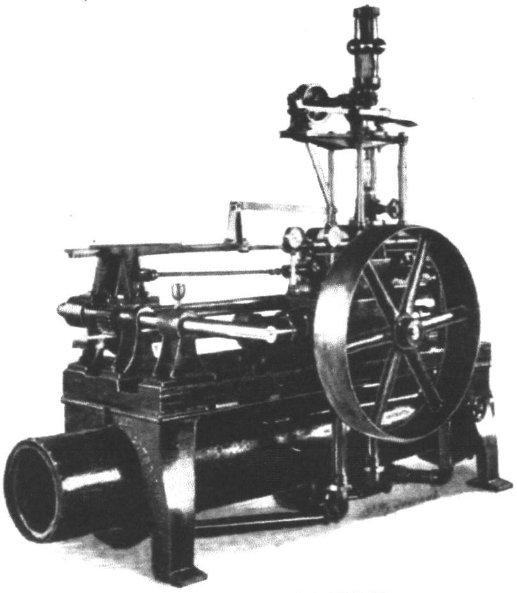


FIG. 7.—TURBINE GOVERNOR.

Two-inch cables will be used for transmitting the 12,000 volt current and for lower pressure a feeder of 500,000 c. m. All feeders will be carried underground and in vitrified clay conduit. Paper insulation will be used throughout, furnished by the National Conduit & Cable Company.

The switchboard will be on the up-stream side of the building, located on a gallery over the turbine chambers, and 18 ft. above the generator floor. It will be of blue Vermont marble in twenty-four panels, each 2 ins. × 28 ins. × 90 ins. The specifications for its design make it impossible to touch a live part on the face of the board. On this gallery, which is 207 ft. × 10 ft., are also the general offices and drafting rooms. It is reached by iron stairways at either end.

The promoter and engineer of this enterprise is Wm. de la Barre, M. Am. Soc. C. E., who, with C. G. Goodrich, vice-president, and E. P. Burch, electrical engineer, of the Twin Cities Rapid Transit Company, has visited almost every important electrical plant in the United States, in order to be fully conversant with the best machinery and designs. The engineering plans and details were prepared under the direct inspection of Axel Ekstrom, of the company's engineering corps. The dam has been projected for years, but actual work did not begin upon it until May, 1895. The work on the dam has been done entirely by day labor, under the supervision of Mr. de la Barre, no contracts of any nature having been let. Every step in the construction has been planned with the utmost care. The entire cost of the work is approximately $500,000, of which $300,000 is, as stated, for electrical equipment.

The Twin Cities Rapid Transit Company can itself consume only a portion of the power to be generated and the surplus will be placed upon the market.

The officers of the Twin Cities Rapid Transit Company are: president, Thomas Lowry; vice president, C. G. Goodrich; general manager, W. J. Hield; auditor, J. F. Calderwood.

Extensive Electric System near Montreal.

The construction of an extensive electric system in Montreal will soon be commenced by the Montreal & South Counties Railroad Company, of which A. J. Corriveau is one of the leading directors. According to Mr. Corriveau, the line will cross the St. Lawrence River on one of the existing bridges and will then run through twelve of the southern counties to St. John's (P. Q.) and Sherbrooke. The whole system contemplated includes 150 miles. Power will be furnished by the Chamblay Water Power Company. The capital of the company is $2,000,000.

Digitized by Google

St. Anthony's Falls Water-Power Plant

The construction of the recently inaugurated water-power electrical generating plant at St. Anthony's Falls was undertaken by the St. Anthony's Falls Water-Power Company, the plant when completed being leased to the Twin City Rapid Transit Company for the purpose of furnishing power to all the street railway systems of both Minneapolis and St. Paul, which are operated by the Twin City Company. The engineers of both the above-named companies worked in unison, and the result is most creditable, whether viewed from the standpoint of hydraulic, mechanical or electrical engineering. It is interesting to note that the plant has supplanted more steam-driven belted electrical machinery with its direct connected generators and rotary converters than any other plant in the world.

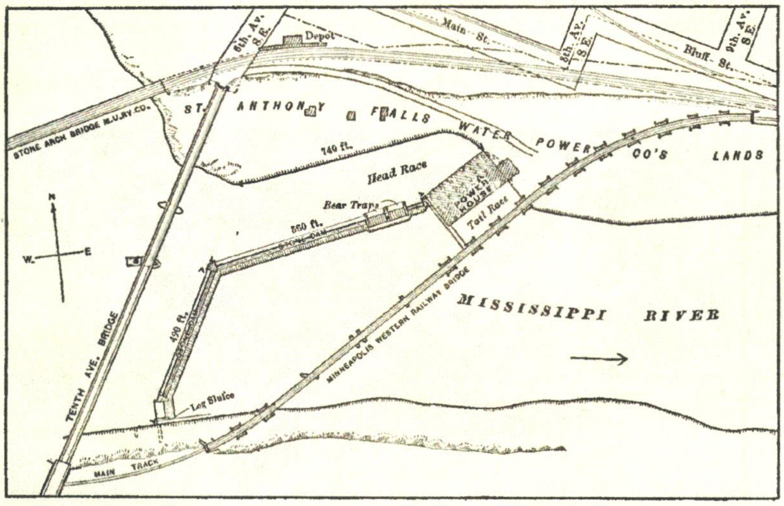


FIG. 1.—MAP SHOWING LOCATION OF PLANT

Three of the old power stations have practically been closed, and are now used as sub-stations for the accommodation of the rotary converters. These, of course, take up much less floor space compared with the former plant; in fact, room enough was obtained to install the converters without removing any of the old plant, the floor space required being very small. A preliminary description of this plant was published in the Street Railway Journal for June, 1897, while the work was in course of construction. Since that time the plant has been put in operation, so that the information given below will be of interest. The map showing the location of the dam and station given in that article is reproduced here for the convenience of reference.

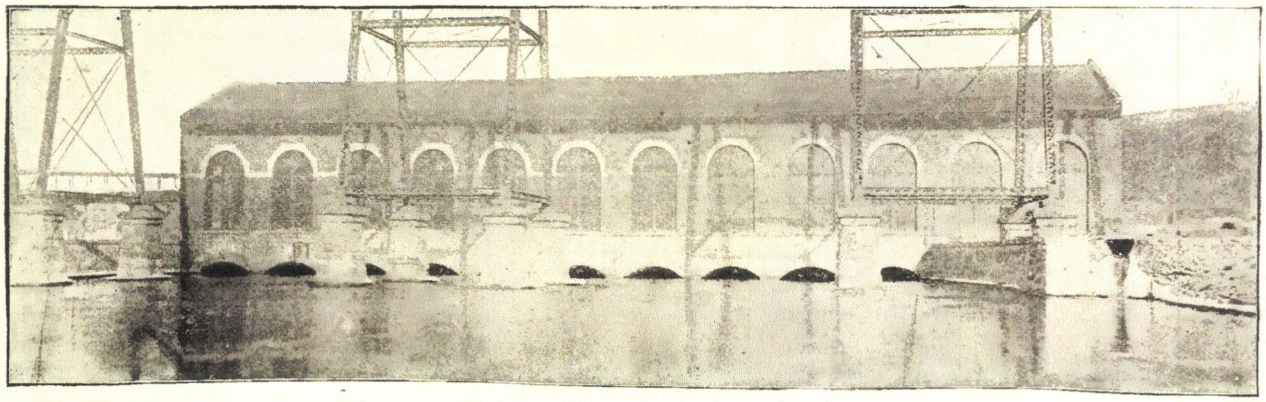


FIG. 3.—POWER STATION AND TAIL RACE

WATER RIGHTS

The site of the present plant is located in Minneapolis, just below the great St. Anthony's Falls of the Mississippi, where there is a long stretch of rapids. The power company has the right for the entire width of the river at this place, but great care has to be taken not to interfere with the water rights of companies located above this plant, for if too much water were held back by the dams of the St. Anthony Company the head above would be considerably diminished. This is amply taken care of in a manner which will be explained later. Fig. 1 is a map of the site of the plant.

MAIN POWER STATION

The power house of the company is located at the end of the main dam, on the north side of the river, as shown in Fig. 3, and in reality forms a portion of the dam. The foundations are all built of cut granite, and the walls are of hollow tiling with sandstone trimmings. A steel frame, as shown in the interior view of the power house (Fig. 4), supplements the wall and supports the roof, which is covered with slate. This cut gives a general interior view of the station, showing the generators which are already installed.

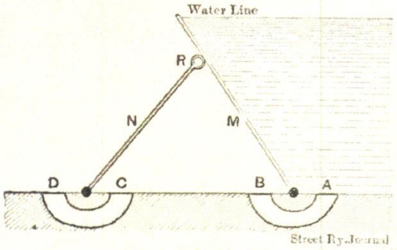


FIG. 2.—BEAR TRAP

The station is 250 ft. long and 80 ft. wide, outside measurement, and there is accommodation for ten 700 k.w. units, directly coupled to horizontal water-wheels. The height of the building from floor to ridge of roof is 45 ft. Ample room is provided, as will be seen in the illustrations, for the installation of engines if it is found necessary to use them at times of low water or when the plant is increased.

The station is also provided with an electric traveling crane capable of handling any of the machinery in the station. The cross-sectional view Fig. 5 represents the station as originally designed. As built, the roof structure is different, and the switchboard gallery is in a recess in the side wall of the electrical generator room, as shown in Fig. 4; the arrangement of the machinery, however, is properly given. Fig. 6 is a plan view of the station, showing the arrangement of the turbines and generators; as actually installed, each unit is not provided with an exciter, as shown, there being two separately driven exciters, as elsewhere described.

HYDRAULIC WORK

The appearance of the dam is partly shown in Fig. 7. The retaining wall which can be seen in this cut extends along the north shore 740 ft. from the power station to a point a short distance beyond, where the wing and head dam form an angle. This wall had to be built for the protection of the bank, and is constructed entirely of cut granite. It forms one side of the fore bay, which is also well shown in Fig. 7.

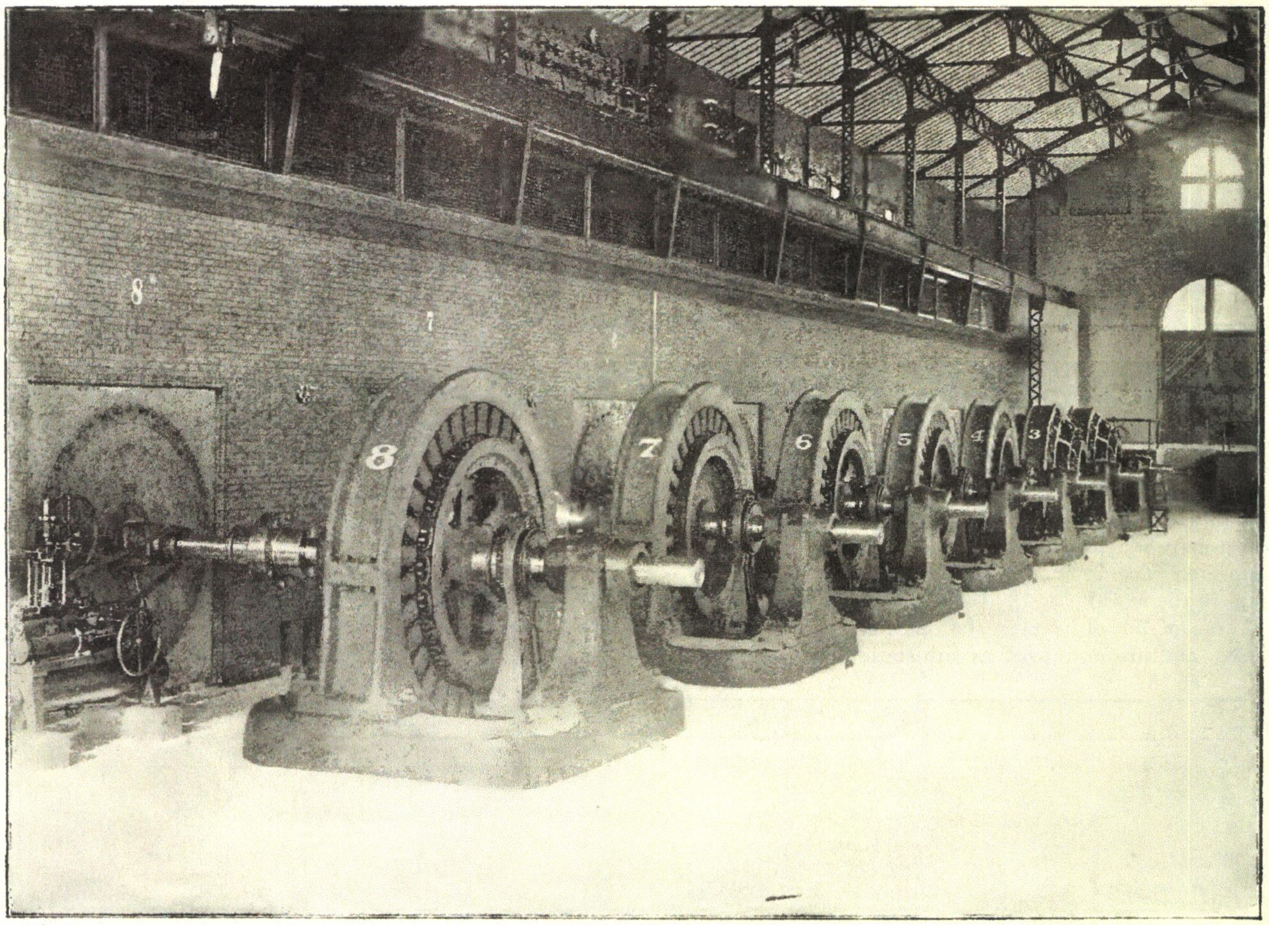


FIG. 4.—INTERIOR OF POWER STATION

As may be seen from Fig. 1, the main cross wall starts from the west bank of the river and runs directly across for a distance of 500 ft. This is the length of the wall proper, and does not include gates or waste ways. It then branches off at an angle and runs down stream nearly parallel to the east bank for 370 ft., to the upper end of the large waste way, shown in Fig. 3, close to the power station. Between the waste way and the power house the wall is continued, but at an increased height. All of the construction is of the best cut granite laid in cement.

As before stated, the power house forms a portion of the dam. There is a rack placed at the fore bay side of the power house, extending its full length, and the water, after passing through this, enters the wheel chamber and flows from the draft tubes into an arched tail race underneath the power house.

In addition to the main wheel chamber, there is another small wheel chamber at the north end of the building, used for the purpose of driving two exciters.

The head is a maximum of 22 ft. and a minimum of 16, with an average of 20. The wheel chamber can be seen from an inspection of Fig. 4, which also shows the switchboard, placed on top of it. In the interior of the power house the wheel chamber is faced for its entire length with glazed brick. Fig. 8 shows the side of this wall, and one of the direct-current generators.

The set of waste gates near the power station, shown in Fig. 7, are known as "Bear Traps." They are made in two sections. The apron, M (Fig 2), forming the gate proper, is hinged at its lowest point, and the support against which it rests, or, more properly speaking, which supports it, is another apron, N, somewhat smaller in size, placed some distance in front of it, and having rollers, R, along the entire top edge. These rollers rest against the outer surface of the main apron.

When the gate is fully open, the supporting apron closes down with the main apron on top of it. The gates are raised by simply opening a valve in a large pipe, AB, under the apron, which allows the water to pass from the fore bay, underneath the gate and underneath the front apron having the rollers along the edge. The pressure of the water is sufficient to raise this gate and maintain it at any desired height. By means of an outlet, CD, from the chamber between the gates, they can be instantly closed by shutting off the water at the intake and opening a valve which allows the water below the gates to escape, when the gates will collapse upon themselves.

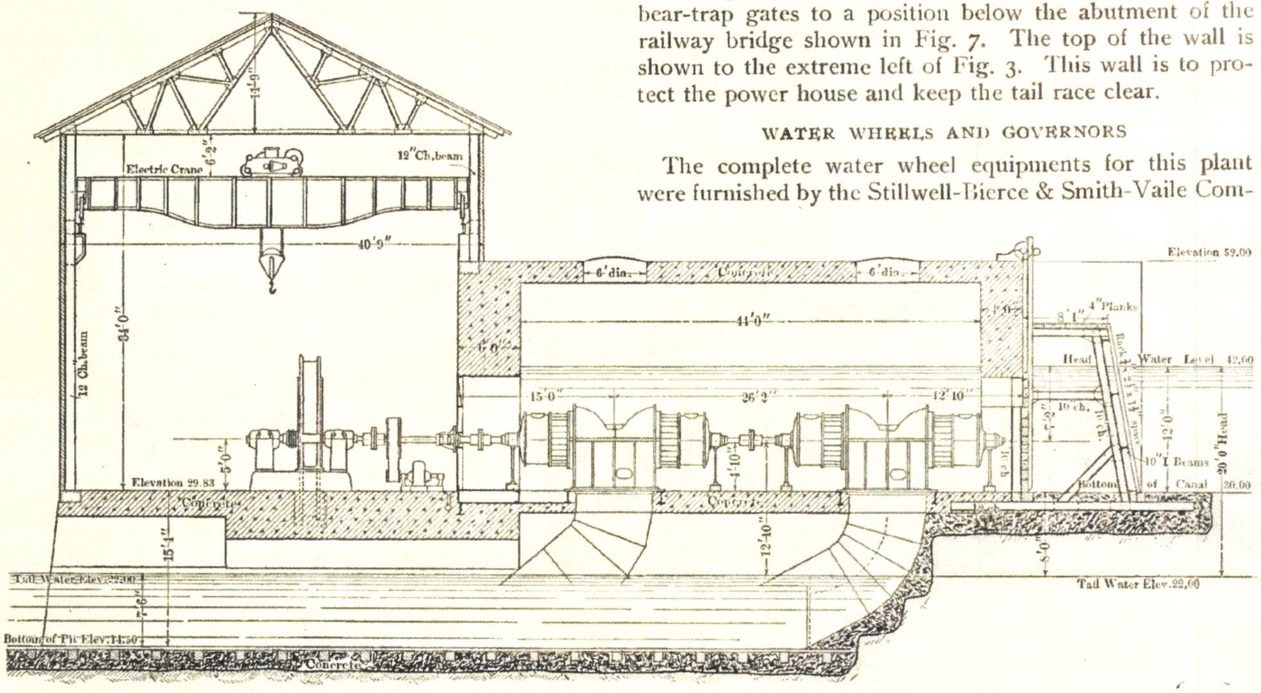

13'9"
6'2"
Electric Crane
12"Ch.beam
40'9"
12 Ch.beam
34'0"
6'dia.
6'dia.
44'0"
15'0"
26'2"
12'10"
8'1"
4"Planks
Head
Water Level 42.00
Elevation 52.00
10 ch.
10"I Beams
Bottom of Canal 30.00
12'0"
20'0" Head
5'0"
4'10"
Elevation 29.83
Concrete
15'4"
12'10"
Tail Water Elev.22.00
Tail Water Elev.22,00
Bottom of Pit Elev.14.50
Concrete

FIG. 5.—CROSS SECTION OF POWER HOUSE

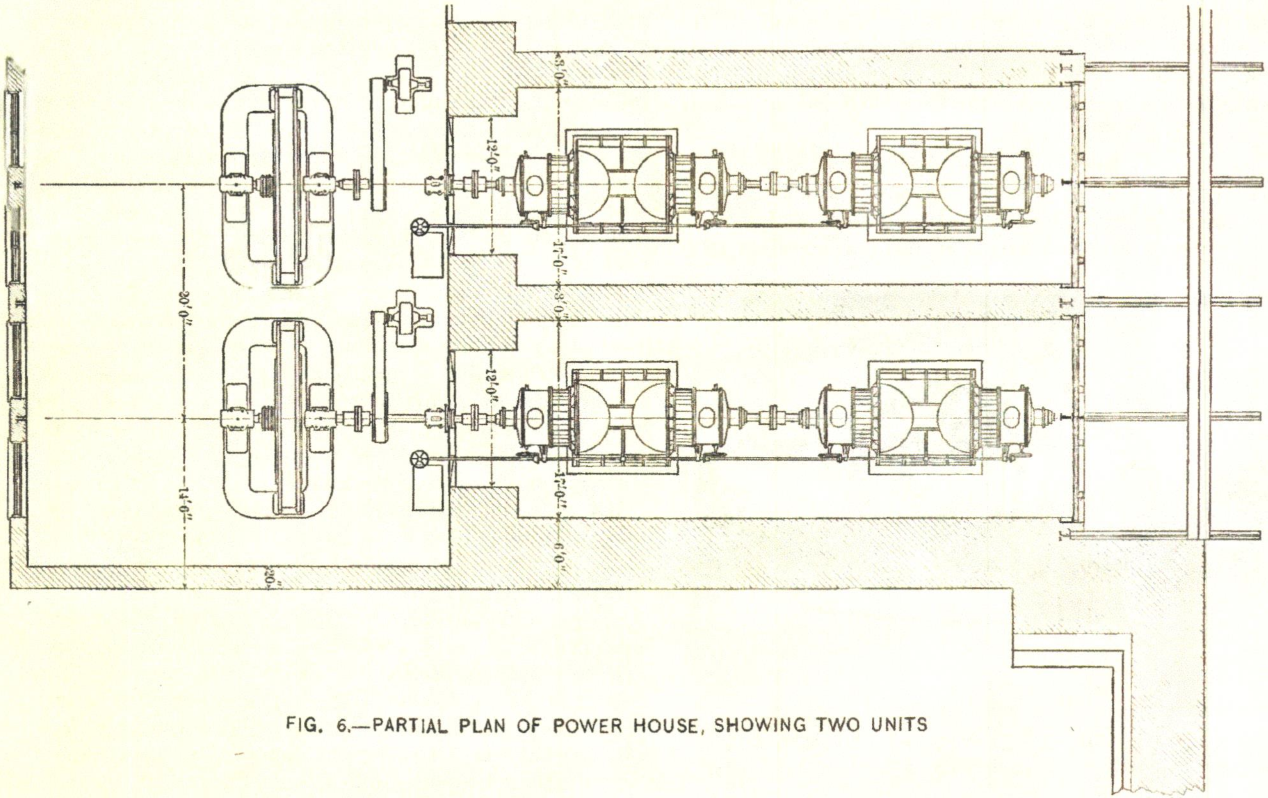

12'0"
17'0"
8'0"
12'0"
17'0"
6'0"
30'0"
14'6"
20'

FIG. 6.—PARTIAL PLAN OF POWER HOUSE, SHOWING TWO UNITS

One of the strongest advantages of this gate is that the water in flowing over carries off all debris which comes into the fore bay, and which would otherwise catch in the racks.

The gates in the south side of the river are of the ordinary slide type, and three in number. They are operated by large screws furnished with ball-bearing nuts and operated by a small water-wheel placed in one of the piers.

In addition to the granite walls forming the dam, there is a wing wall running from the power-house side of the bear-trap gates to a position below the abutment of the railway bridge shown in Fig. 7. The top of the wall is shown to the extreme left of Fig. 3. This wall is to protect the power house and keep the tail race clear.

WATER WHEELS AND GOVERNORS

The complete water wheel equipments for this plant were furnished by the Stillwell-Bierce & Smith-Vaile Company, and are of the well-known Victor type. As shown in Fig. 6, to each 700 k.w. unit there are two pairs of 42-in. horizontal wheels, giving a total of four 42-in. wheels directly connected with each generator shaft. These wheels are designed and guaranteed to develop 1,000 h.p. per set, or 250 h.p. each.

This method of installing wheels is an innovation in low head work, and forms an exceedingly compact and efficient unit. The shafts, with couplings attached, can be seen in Fig. 4 projecting through the wheel chamber wall.

In addition to the wheels just described there are two sets in the wheel chamber at the east end of the house, which were manufactured and installed by the D. S. Morgan Water Wheel Company. These wheels are for the purpose of operating generators for furnishing exciting current to all the three-phase generators in the station.

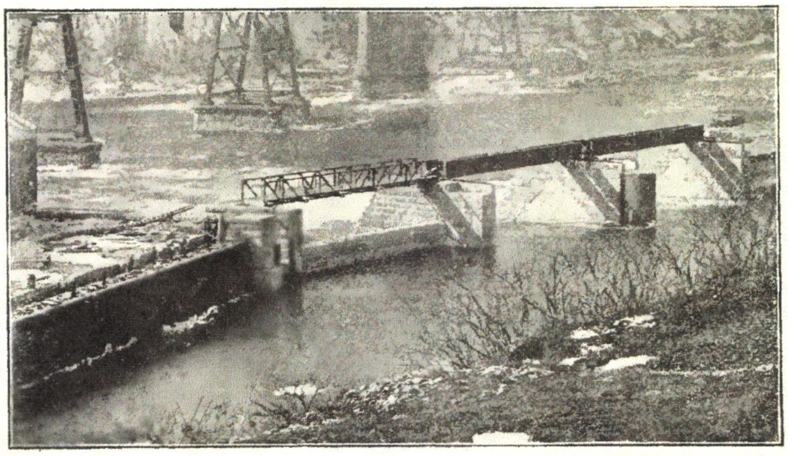


FIG. 7.—VIEW OF BEAR TRAPS

The governors were furnished by the Lombard Water Wheel Governor Company. The governor is very well shown in Fig. 8, and is driven by a belt connected to a small pulley on the generator shaft. The excellent result given by these governors in other installations leaves no question as to their satisfactory operation in this plant. Each governor operates the gates for each full set of four wheels.

ELECTRICAL APPARATUS

The electrical apparatus installed was manufactured by the General Electric Company. In the main station there are at present installed five 700 k.w. three-phase generators, having 32 poles, and operating at a speed of 130 revolutions, giving a frequency of about 35. One of these is shown in Fig. 9.

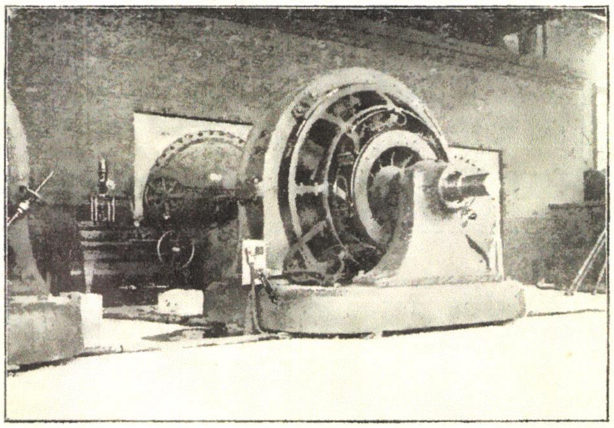


FIG 8—ONE OF THE DIRECT CURRENT GENERATORS, AND GOVERNOR

The base frame is so constructed that the field frame can be moved parallel with the shaft for the purpose of cleaning the armature or for repairs. The approximate weight of the armature is 25,000 lbs., and the complete weight of each machine about 84,000 lbs.

In addition to these machines, there are two direct-current 700 k.w. generators, having eight poles, and running at a speed of 130 revolutions per minute. These machines are wound for a pressure of 575 volts at no load, and over-compounded to a voltage of 600 volts at full load. They feed the 500-volt circuit direct from the power station, through five 500,000 C. M. cables.

The armature is of the well-known ironclad type, and is ventilated by means of ducts in the armature .4 in. in width. The armature winding on these machines consists of copper bars laid in the slots, the winding being of the type known as the "barrel."

The commutator is designed so that the current density at the point of contact with the brushes does not exceed 35 amperes per square inch at the full rating of the machine, and the difference of potential between commutator bars is very low.

There are two 100 k.w. six-pole exciters, running at a speed of 280 revolutions per minute, and wound for a voltage of 575 volts at no load, and over compounded to 600 volts at full load. These machines have armatures of the ironclad type, ventlated in practically the same manner as the machines previously described.

The switchboard installed in the station was especially designed with a view to having two separate sets of busbars, so that the attendant in charge may run any particular machine on either of the two busbars. A view of all connections of the main station and switchboard is shown in Fig. 11. This sketch shows the connection of the main station to all generators, and also the three rotary converter sub-stations. There have been some minor modifications made in the wiring since this wiring diagram was made, but none that are worthy of note, with the exception of the circuit to the St. Paul sub-station, which has only one circuit from the power-station. The switchboard consists of twenty-three panels as follows:

One station panel, equipped with one 750-volt, illuminated dial Weston voltmeter, one 2500-ampere, 600-volt, Thomson recording wattmeter, the panel being surmounted with a 12-in. dial, eight-day clock, and head piece.

Five alternating-current generator panels, each equipped with one 200-ampere, dead-beat, inclined coil ammeter; one 5250-volt, inclined coil voltmeter and station transformer; one generator rheostat; one high-voltage main switch (porcelain chamber); two single-pole field switches; one two-point phase lamp switch; two pilot lamps; one phase lamp; one potential plug; one 700 k.w. single-phase indicating wattmeter and three fuse blocks.

Two continuous-current railway generator panels, each equipped with one 1200-2000 ampere circuit breaker; one 2500 ampere illuminated dial Weston ammeter; one generator rheostat; one lightning arrester; two single-pole, double-throw main switches; one lightning switch; one two-way field switch; one potential plug; one pilot lamp; one resistance lamp; two bus wires on the back. (Equalizer switches are furnished, but are located at the generator.)

Five alternating-current feeder panels, each equipped with one 200-ampere, dead-beat, inclined coil ammeter; one 200-ampere, 3500-volt, alternating, three-phase Thomson recording wattmeter, and two station transformers; three porcelain chamber, high-voltage triple-pole switches; one pilot lamp; six busbars at the back; one indicating wattmeter, 700 k.w. capacity (single-phase type), and three fuse blocks.

Eight special railway feeder panels, each equipped with two 300-500-ampere, circuit breakers; two 200-ampere, round pattern, Weston ammeters; one pilot lamp; two single-pole main switches; two busbars at the back.

Two exciter panels, each equipped with one illuminated dial Weston voltmeter; one round pattern Weston ammeter; one rheostat; two single-pole, double-throw, main switches; two single-pole field switches; two busbars at the back; one automatic circuit breaker.

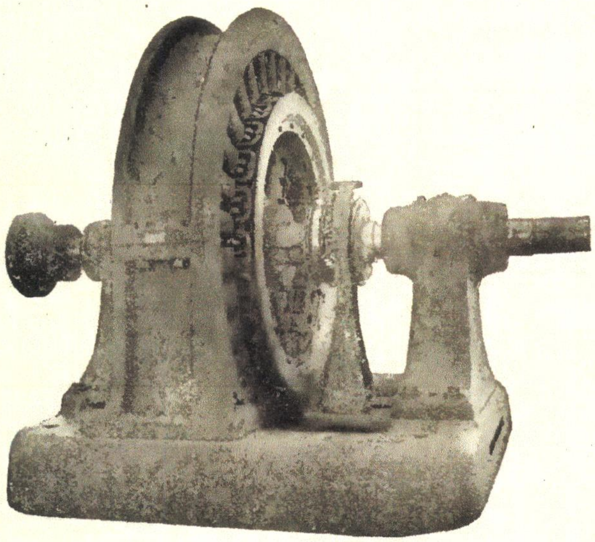


FIG. 9—700 K.W THREE-PHASE GENERATOR

TRANSFORMERS

The static transformers employed in this plant are of the standard air-blast type, and are twenty-one in number, of 233 k.w. capacity each. Six of these are placed in the main station for the purpose of raising the generator voltage from 3450 to 6900 volts, and the remaining 15 are placed in the three sub-stations, two containing six, and the third three.

This type of transformer is too well known to need an extended description, although it might be interesting to refer to some of the most important features of its construction.

The first and greatest aim in the manufacture of any transformer is to thoroughly insulate the high potential from the low potential windings. This is accomplished in this transformer by the method of cooling, which admits of a heavy insulation being placed on the coils without unduly restricting the radiation of heat. In addition to this, solid diaphragms of heavy insulation are placed between the high and low potential coils. Air ducts separate this diaphragm on either side from the adjacent coils.

How effectively this insulation fulfills its duty may be judged from the fact that the transformers for this plant were tested with a 20,000-volt potential between primary and secondary windings, and it could have safely been tested for considerably higher voltages. Transformers of this type have been built for higher voltages with similar insulation, and have successfully withstood a test of 80,000 volts.

Another one of the problems connected with the building of large electrical apparatus is to properly dispose of the heat generated within the windings. This problem has been very successfully met in electrical apparatus which has revolving parts by so designing these parts that they act as blowers, thereby forcing currents of air through the revolving parts. It is not surprising then that this method, which has proved so thoroughly satisfactory in revolving apparatus, should prove equally satisfactory in static transformers.

In order to present the proper amount of surface to the circulating air, the coils of the transformers are separated from each other by narrow air ducts, and the sheet iron of which the transformer core is composed is separated into small groups by similar ducts.

The air is forced through the main duct which runs underneath all of the transformers. This forced draft is obtained from an electrically driven blower set, and the air, after passing through the coils in the core, escapes into the surrounding atmosphere having absorbed the heat in its passage through the transformers.

So carefully and thoroughly has this system been carried out that each transformer has some 350 sq. ft. cooling surface. As a result, no portion of the windings has a temperature rise of more than 35 degrees C. above the surrounding air after having carried their full rated load for an indefinite time.

It is a fact worthy of note that this very effective cooling is accomplished with an expenditure of power of only one-tenth of one per cent of the capacity of the transformer.

The efficiency of these transformers is a fraction under 98 per cent. While this is not as high an efficiency as can be obtained in the design of transformers, it represents practically the most economical design where power is as cheap to produce as it is in this plant. Good regulation rather than extremely high efficiency is, of course, to be desired in water-power plant, and consequently the transformers were designed for the very close regulation of 1 per cent from no load to full load.

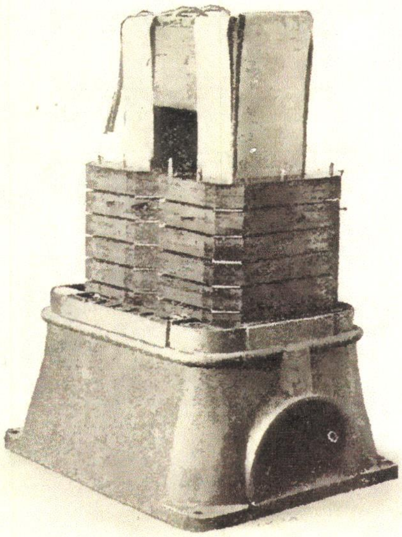


FIG. 10—CONSTRUCTION OF AIR-BLAST TRANSFORMER

As is seen from Fig. 10, the transformers are compact and of neat appearance. They are thoroughly protected by an enclosure case, no portion of the windings being exposed. The high potential coils have their terminals brought out through the casing in porcelain bushings, and rubber-covered cables connect these terminals to the lines. Fig. 10 shows the transformer with the casing removed. The dimensions of the transformer are—height, 58 ins.; floor space, 38 ins. x 32¾ ins.; weight, approximately, 4500 lbs.

INDUCTANCE COILS

A three-phase open magnetic circuit inductance coil is placed between the transformer and each rotary in order to give greater range of adjustment of the direct current voltage of the rotary.

On most power transmissions there is sufficient inductance in the system, due principally to the inductance of the line, to allow a considerable range of adjustment in the voltage of the rotary by changing the field excitation, without any considerable idle current being produced.

In this transmission, due to the comparatively short distances between generator and rotary and to the extensive use of cable rather than overhead line, the inductance of the system is so low that tne introduction of this artificial inductance is necessary in order to get the desired flexibility in the voltage.

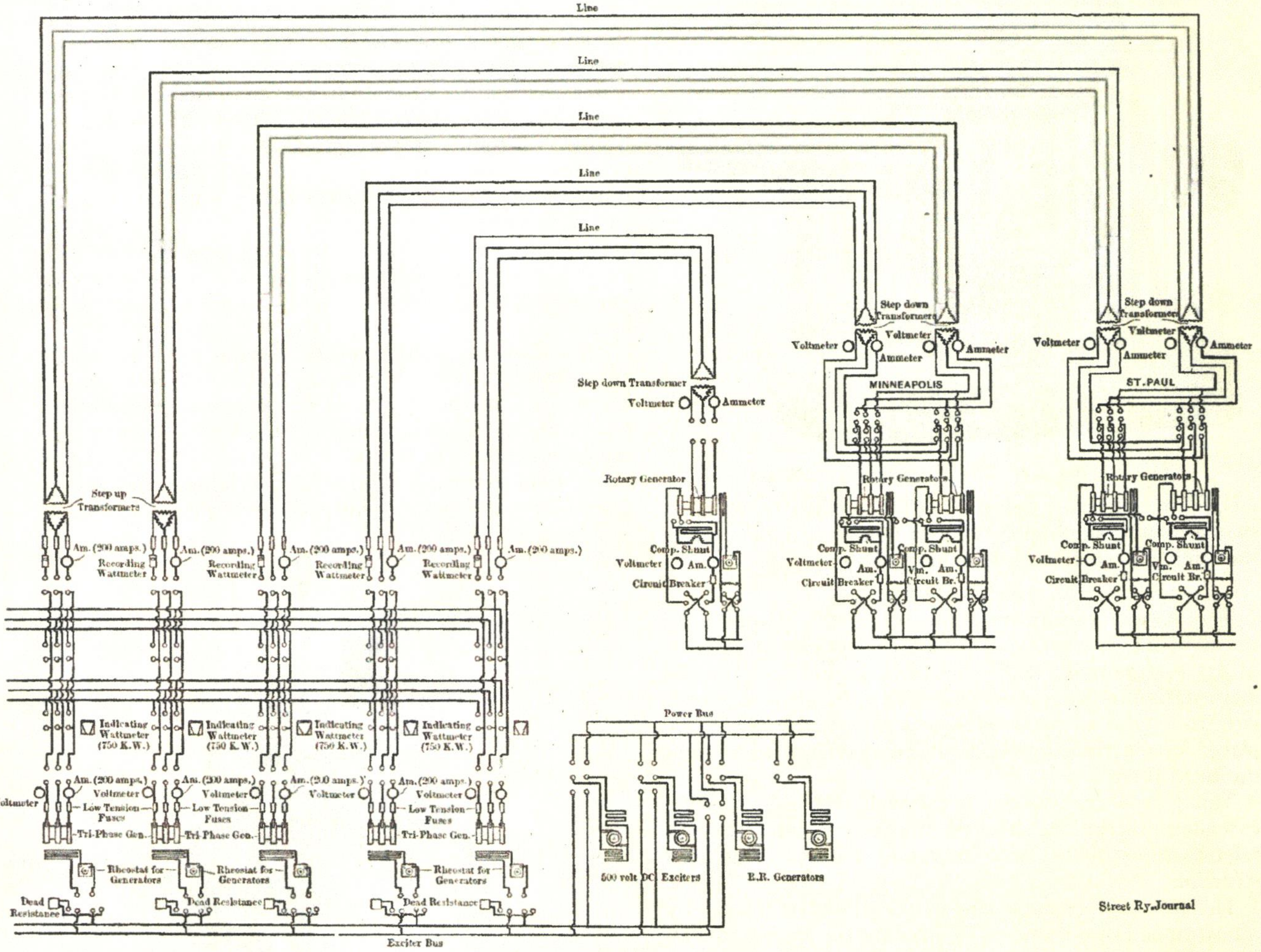

Line
Line
Line
Line
Line
Step up Transformers
Am. (200 amps.)
Recording Wattmeter
Step down Transformers
Voltmeter
Ammeter
MINNEAPOLIS
ST. PAUL
Step down Transformer
Rotary Generator
Rotary Generators
Comp. Shunt
Am.
Vm.
Circuit Breaker
Circuit Br.
Indicating Wattmeter (750 K.W.)
Low Tension Fuses
Tri-Phase Gen.
Rheostat for Generators
Dead Resistance
Power Bus
500 volt DC Exciters
E.R. Generators
Exciter Bus
Street Ry. Journal

FIG. 11—GENERATING AND SUB-STATION CONNECTIONS

ROTARY RECONVERTERS

There have been installed in the three sub-stations five rotary converters. Two of these converters are in what is known as Sub-station No. 1, located in the heart of the city of Minneapolis, and are 9,000 ft. from the power station, current being transmitted at a pressure of 3500 volts over two triple-conductor, paper-insulated, lead-covered cables, each conductor equal to 3-0 B. & S. furnished by the National Underground Conduit & Cable Company; one is in Sub-station No. 2, located in Minneapolis and 23,700 ft. distant from the power station, and operated at the same potential as No. 1 Station, by one triple-conductor cable, each conductor equivalent to 4-0 gage; two are in Sub-station No. 3, located in St. Paul, distant ten miles from the power station. The current is transmitted at a potential of 12,000 volts through one triple-conductor cable, made up of three 1-0 B. & S. wires.

These converters are of the 8-pole type, of 600 k.w. capacity each, and operated at a speed of 530 revolutions, giving 580 volts on the direct-current sides at all loads up to normal.

The armature is of the iron-clad type and is thoroughly ventilated by means of 5-16 in. ducts. The armature spider is calculated for a safety factor of 6, and so constructed that all shrinkage strains are obviated; the laminae are dovetailed into the armature spider, dispensing with the use of bolts in the core.

The commutator is assembled on a separate spider mounted upon the armature spider. The voltage delivered to the A. C. side of the rotaries is approximately 350 volts.

SUB-STATION SWITCHBOARD

The switchboards for the three sub-stations will consist of ten blue Vermont marble panels, divided into three units, two having two alternating and two direct-current panels, and the other one alternating and one direct-current panel.

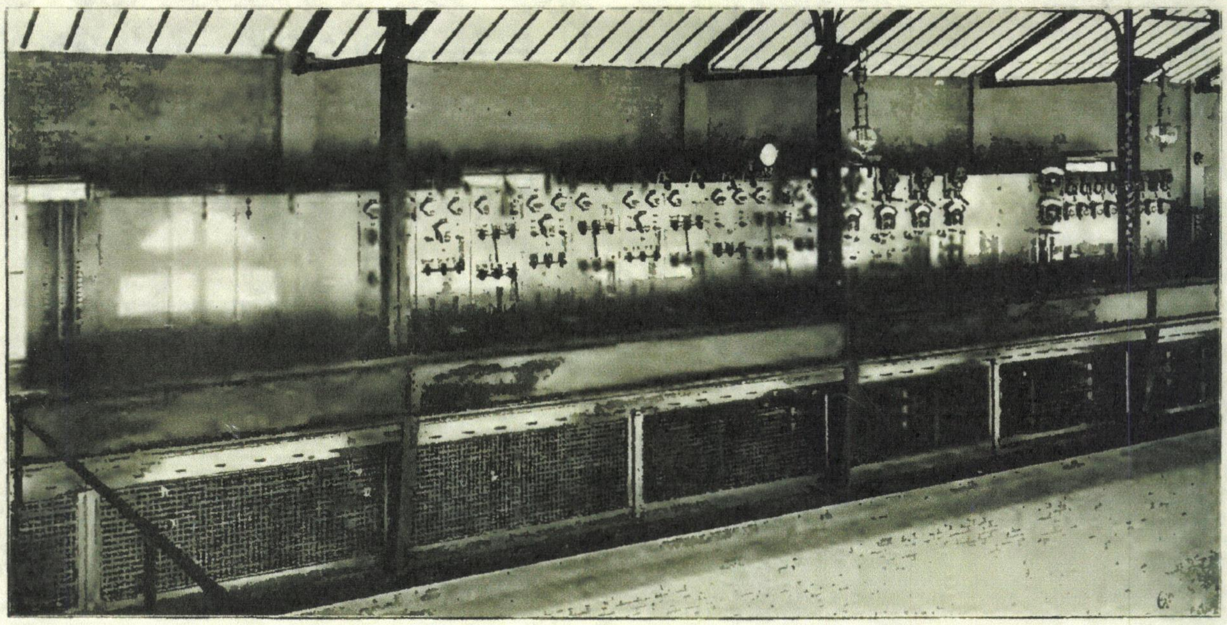
Each continuous current panel will be equipped with the following apparatus: One 650-volt, inclined coil, dead-beat voltmeter; one 1500-ampere, inclined coil, dead-beat ammeter; one pilot lamp; one potential plug; six single-pole, quick-break switches.

The hydraulic work of the plant was constructed by local contractors, supervised by William de la Barre, engineer of the company. The electrical work was in charge of Edward P. Burch.

Power House and Shops of Twin City Rapid Transit Company.

Description of the Water Power Plant at St. Anthony's Falls — Method of Distributing Current — Changes Effected in Old Stations — Description of the General Shops of the Company and of the New Car Shops — Standard Double Truck Car for City Use — How Accidents Have Been Reduced by Gates and Fenders.

The Twin City Rapid Transit Company was chartered in June, 1891, under the laws of New Jersey, but the three companies which it controls, the Minneapolis Street Railway Company, the St. Paul City Railway Company, and the Minneapolis, Lyndale & Minnetonka Railway Company, are much older. The men who are now managing this company were interested in the street railways of the Twin Cities before the motive power was electricity and were pioneers in electrical working. Thomas Lowry, the president, was among the first to recognize the future of electricity in the street railway field, and though he had decided upon a cable system and purchased large quantities of material, did not hesitate to change his plans and use the newer power. C. G. Goodrich, the vice-president, has been connected with this system for over 20 years, and W. J. Hield, the general manager, for nearly 12 years. Both have been untiring in their efforts to develop the business, and the success achieved crowns the work. The auditor of the company, John F. Calderwood, is well known to the street railway men of the country through his connection with the Street Railway Accountants' Association, of which he is president, and as a member of its committee on a standard system of accounts.



VIEW OF SWITCHBOARD.

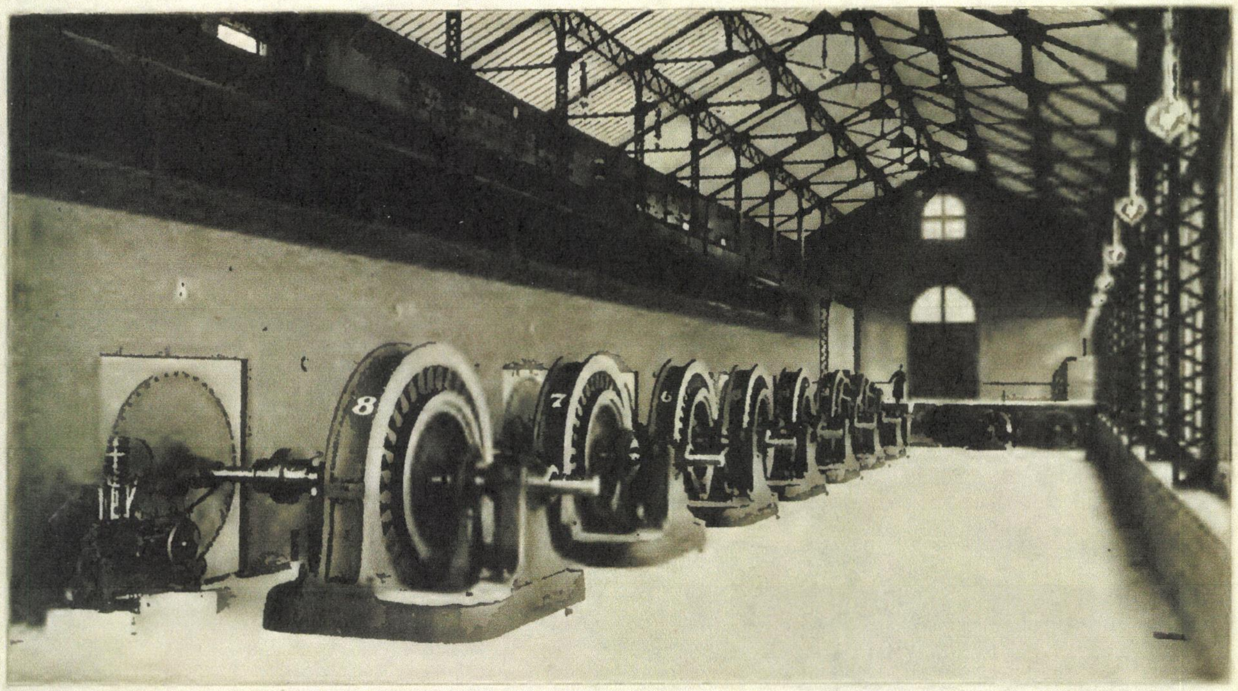
At the present time the company operates about 240 miles of track. Since acquiring the St. Paul & Suburban road it has all the street railways in and connecting the two cities and their suburbs. The various lines are shown in the map of the system published herewith. The equipment comprises about 1,000 cars, of which over 600 are motor cars. The great majority of the cars are run in one direction only, Y's being provided at all terminals, and hence have but one controller. The exceptions are cars put on intermediate sections of lines where there is a heavy local traffic during portions of the day; on these lines cross-overs are provided and the cars are run back and forth without turning.

Double truck cars are favored because they are more popular with patrons and cheaper to operate under the conditions which obtain, and, it is believed, are also cheaper to maintain. The large cars are heavier and require more power, but the capacity is greater and the increased cost of power is more than compensated by the saving in trainmen's wages. A single large car will replace a small car and trailer, dispensing with the need of one conductor. This reduction of one-third in the item of wages, about 40 per cent of the operating expense, permits a comparatively large increase in the item of power, which is only about 15 per cent of the total. Also by substituting one car for a two-car train the number of safety gates is reduced. As fast as possible the old cars will be superseded by new ones of the standard type.

One year ago the power used by the company was generated at three separate stations, two of which, known as Nos. 1 and 2, were in Minneapolis and one, No. 3, in St. Paul. The aggregate power of the engines then in use was 10,500 h. p. The plant of the St. Anthony Falls Water Power Company was first put in partial operation January 1, 1898, and was in full operation by February 19, 1898, since which time the old No. 1 power station has been run but 11½ hours, and No. 2 has been abandoned. It was not intended to entirely supplant No. 3 station by the water power plant, and this station still carries a portion of the regular St. Paul service.

The power station of the St. Anthony Falls Water Power Company is located on the north side of the Mississippi river, at the end of the company's dam, which is commonly called the lower dam. This company owns all of the St. Anthony's Falls water rights, and years ago built the upper dam and leased power to the various mills located on both sides of the river at this point. The fall at the upper dam is 48 ft., and when the lower dam was built its height was limited by the necessity of not interfering with the water power of the mills above. At the lower dam the available head varies from 16 ft. to 21 ft., depending on the stage of the river; the average available acting head is 19 ft. The location of the plant is shown in the accompanying map.

As seen from this map the building is a part of the dam; it has foundations of cut granite and walls of hollow tiling, with sandstone trimmings. The building from outside to outside is about 250 ft. long by 100 ft. wide. The northern portion, constituting the wheel pits, has walls extending 20 ft. above the flood level (which is the same for the wheel pits as for the generator room); this portion is 44 ft. wide, inside measurement. The generator room is about 48 ft. wide at the floor, but the north wall of this room is built over the wheel pits so that a gallery 12 ft. wide is formed at one side. In this gallery are placed the switchboard and transformers. The office of the electrical engineer of the Twin City Company, Edward P. Burch, is also located near the front end of the gallery. From the floor of the generator room to the top of the side walls is 34 ft.; to the ridge of the roof, 45 ft. The roof is of slate, supported on steel trusses. A 40,000 lb. crane, built by Pawling & Harnischfeger, of Milwaukee, travels the entire length of the building.



INTERIOR OF POWER HOUSE.

The dam, as shown in the map, extends in a northeasterly direction, almost parallel to the 10th avenue bridge, for a distance of 400 ft., and then turns at an angle and runs parallel to the northern shore for 544 ft.; at the southern end is a log sluice and near the power house are two bear trap waste gates. The dam is built of cut lime stone laid in concrete cement. To protect the shore a retaining wall, also of granite, was built from the east end of the station to a point opposite the angle in the dam.

The so-called bear trap gates consist of two aprons pivoted at their lower edges and inclined toward each other. One, the lower or down-stream apron, is shorter than the other, which is the gate proper, and has rollers along its upper edge against which the upper apron rests. To raise the gate water is admitted to the space between the two aprons, through a by-pass under the up-stream apron, and forces the two gates up. To lower the gates the upper by-pass is closed and a by-pass connecting the space between the aprons with the water below the dam. As the water flows out from under the aprons they fall, and when completely open the two lie flat, one over the other. The gates at the south end of the dam are three vertical gates operated by screws with ball-bearing nuts. These are operated by a small water wheel.

There is also a wing dam extending from the power house side of the bear traps down below the abutment of the Minneapolis Western Railway bridge, which crosses just east of the power house. This wing dam serves to keep the tail-race clear and protect the power house.

In the main wheel chamber are 14 pairs of 42-in. horizontal water wheels, made by the Stilwell Bierce & Smith Vaile Company; they are of the Victor type. Under the head available these wheels are guaranteed to develop 250 h. p. each. They are mounted in pairs and two pairs coupled, making four 42 in. wheels driving each of the seven generators now installed. At the east end of the power house, in a smaller wheel chamber, are two sets of wheels made by the S. Morgan Smith Water Wheel Company.

The governors were made by the Lombard Water Wheel Governor Company, and seven of them are now installed.

The machines installed now comprise five 700 k. w. three-phase General Electric alternators, with 32 poles, running at 130 r. p. m., giving a frequency of about 35; two 700-k. w. G. E. 8 pole direct current generators, wound for 575 volts at no load and 600 volts at full load; and two 100 k. w. six pole exciters running at 280 r. p. m., giving 575 volts at no load and 600 volts at full load.

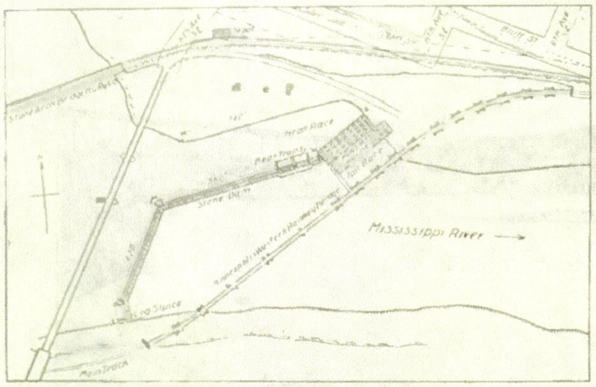
The switchboard is of Vermont marble, with 28 panels, six of which are now blank for the machines not yet installed. The plant was built to contain ten 700 k. w. machines. A good idea of the size and extent of the switchboard may be had from the illustration. The station panel is fitted with one 750-volt illuminated dial Weston voltmeter and one 2,500-ampere, 600-volt Thomson recording wattmeter. The alternating current panels are each equipped with one 200-ampere, dead-beat, inclined coil ammeter, one 5,250-volt voltmeter, one generator rheostat, one high-voltage main switch with porcelain chamber, two single-pole field switches, one two-point phase lamp switch, two pilot lamps, one phase lamp, one potential plug, one 700-k. w. single-phase indicating wattmeter and three fuse blocks.

There are five alternating current feeder panels, each fitted with one 200-ampere, 3,500-volt three-phase Thomson recording wattmeter, three porcelain-chamber, high-voltage coupling switches, one pilot lamp, six busbars at the back, one single-phase indicating wattmeter of 700 k. w. capacity, and three fuse blocks.

The panels for the two continuous current generators are each equipped with one 1,200-2,000 circuit breaker, one 2,500-ampere illuminated-dial Weston ammeter, two single-pole, double-throw main switches, one two-way field switch, one potential plug, one pilot lamp, one resistance lamp and two busbars at the back.

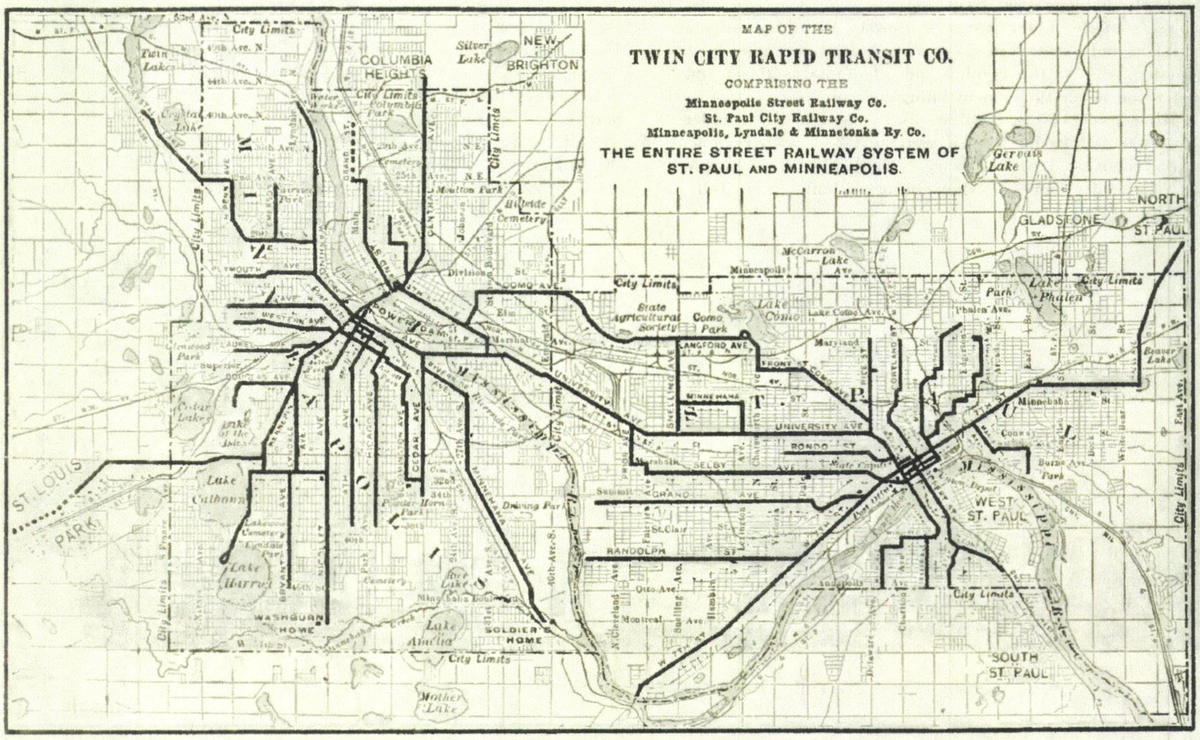
The two exciter panels are next the generator panels and have each one illuminated dial Weston voltmeter, one Weston ammeter of the round pattern, one rheostat, two single pole, double throw main switches, two single-pole field switches, one automatic circuit breaker and two busbars at the rear.

Each one of the railway feeder panels has mounted upon it two 300-500 ampere circuit breakers, two 200-ampere Weston ammeters of the round pattern, one pilot lamp, two single-pole main switches, and there are two busbars at the back.


Mississippi River →
Stone Dam
Head Race
Tail Race
Log Sluice
Main Track
Bluff St

MAP OF DAM.

One panel of the switchboard is designed for the purpose of taking care of static discharges. Two divisions are for the 3,500-volt circuits and the third for the 12,000-volt circuit, the latter having a greater number of discharge gaps and more graphite resistance; otherwise, it is the same as the other two. These are connected to the line through switches and can be opened at any time without interrupting the flow of current in the line. This is for the purpose of cleaning and adjusting the discharge gaps with safety. Surmounting the central panel of the switchboard, as a head piece, is a 12 in. dial. The switchboard, which is in a gallery above the generators, as a whole, is a very handsome piece of work.


MAP OF THE
TWIN CITY RAPID TRANSIT CO.
COMPRISING THE
Minneapolis Street Railway Co.
St. Paul City Railway Co.
Minneapolis, Lyndale & Minnetonka Ry. Co.
THE ENTIRE STREET RAILWAY SYSTEM OF
ST. PAUL AND MINNEAPOLIS.
COLUMBIA HEIGHTS
NEW BRIGHTON
Silver Lake
Twin Lakes
Crystal Lake
City Limits
Lake Calhoun
Lake Harriet
Lake of the Isles
Cedar Lake
Lake Amelia
WASHBURN HOME
SOLDIER'S HOME
Mother Lake
Lake Como
Como Park
McCarron Lake
Lake Phalen
Gervais Lake
GLADSTONE
NORTH ST. PAUL
WEST ST. PAUL
SOUTH ST. PAUL
ST. LOUIS PARK
UNIVERSITY AVE
RONDO ST
SELBY AVE
GRAND AVE
RANDOLPH ST
MISSISSIPPI
State Agricultural Society

At the west end of the switchboard gallery are six G. E. static transformers of the standard air blast type. They are each of 223-k. w. capacity, and are used to raise the voltage of the generators from 3,450 to 12,000 volts for transmission to St. Paul.

EXTERIOR OF POWER HOUSE.

The building is heated by means of home-made electric heaters and lighted by 13 arc lamps.

The hydraulic work of this plant was in charge of William de la Barre, engineer of the St. Anthony Falls Water Power Company; and the electrical work in charge of Edward P. Burch, electrical engineer of the Twin City Company. Mr. Burch has been with the company for seven years.

The entire output of this plant is leased to the Twin City Rapid Transit Company. Current is transmitted to the three stations of the company in the two cities.

Current is transmitted to station No. 1, which is in the business heart of Minneapolis, through two triple-conductor, paper insulated, lead covered cables, each equivalent to No. 000 B. & S. wire. The distance is 9,000 ft.; voltage, 3,450. In the station are six 215-

k. w. transformers of the General Electric A. B. type, transforming from 3,300 to 366 volts, and two 600 k. w., 8-pole rotary converters running at 520 r. p. m., and giving 580 volts up to full load.

This station formerly contained two triple expansian Allis Corliss engines, with cylinders 24, 40¾, and 56 by 60 in., one simple Allis-Corliss of 400 h. p. and one vertical engine of 400 h. p. The two smaller engines have been removed to make place for the converters and transformers. The triple-expansion engines each have flywheels 28 ft. in diameter and 73 in. face, which drive through jack shafts 16 Edison 175 k. w. and two Edison 89-k. w. generators. The old boilers, two Stirling boilers (2,875 sq. ft. of heating surface each) and five Babcock & Wilcox boilers (3,128 sq. ft. of heating surface each) are still in place, though regularly used only for heating the building.

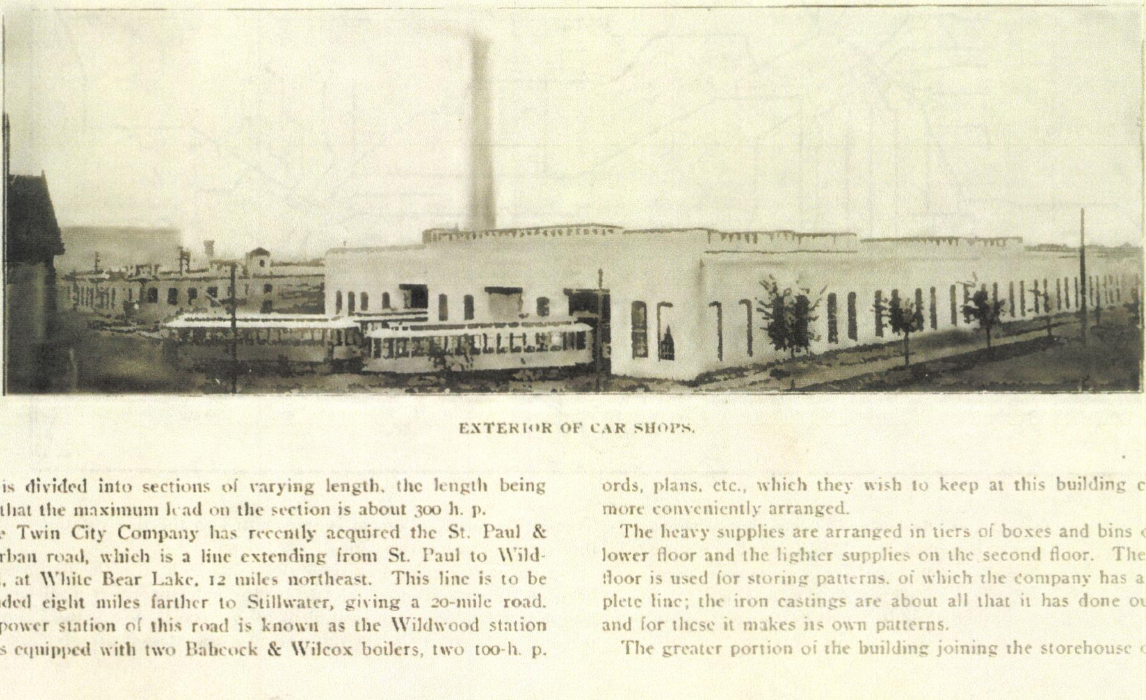
The two triple-expansion engines are available as a reserve. During 1898, after February 19, they were run but 11½ hours, and that was during the severe snow storm of November last, when the water was somewhat low in the river and the demand for power was exceptionally heavy, because the use of snow plows had to be continued during the peak of the railway load.

No. 2 station is in Minneapolis, about 4½ miles from the water power plant, and current is transmitted to it at a voltage of 3,450 over one cable equivalent to a No. 0000 wire. No. 2 contains one 600-k. w. converter and three transformers. This station formerly contained ten 16 and 27 by 16 in. Westinghouse compound engines direct belted to m. p. 270-k. w. T.-H. generators, and seven Stirling boilers of 287 nominal h. p. each. The engines have been removed from this station, but the boilers remain in place and some of them are used for heating the building.

Current is taken to station No. 3, which is in St. Paul, a distance of about 10 miles, over one triple conductor cable of three No. 0 wires. Here are two converters and six transformers. No. 3 formerly contained three triple-expansion Allis-Corliss engines with cylinders 24, 40¾ and 56 by 48 in., and one 400-h. p. engine; the small engine has been discarded. As before stated, No. 3 still carries a part of the regular load.

The cables from the water power station to the three sub-stations are all laid underground in cement lined sheet iron pipe, there being about 100,000 ft. of this conduit laid. The pipe is 4¼ in. outside diameter and inside the cement lining measures 3 in.

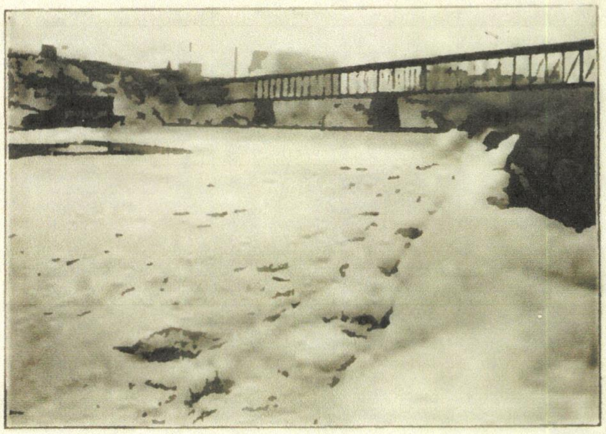
In both Minneapolis and St. Paul are extensive systems of underground low potential feeders which were installed in 1890, when the lines were converted to electricity. These have been supplemented by overhead feeders as extensions were built. The trolley wire is divided into sections of varying length, the length being such that the maximum load on the section is about 300 h. p.



EXTERIOR OF CAR SHOPS.

The Twin City Company has recently acquired the St. Paul & Suburban road, which is a line extending from St. Paul to Wildwood, at White Bear Lake, 12 miles northeast. This line is to be extended eight miles farther to Stillwater, giving a 20-mile road. The power station of this road is known as the Wildwood station and is equipped with two Babcock & Wilcox boilers, two 100-h. p. Ideal engines and two m. p. 4-pole, 90-k. w., T.-H. generators. There is a heavy trafic between St. Paul and White Bear Lake, which is cared for by this station.

The Twin City Rapid Transit Company does a great deal of its own work, probably more than most other roads of the same size, and has extensive shops occupying an entire block in Minneapolis, bounded by West 31st and West 32nd streets and Nicollet and Blaisdell avenues, south. The ground plan of this plant is shown herewith.



THE LOWER DAM.

The building on the northwest corner of the lot is about 65 ft. by 95 ft., three stories high, and was built in 1890; it is occupied by the general storehouse and the offices of the purchasing agent and general store-keeper, A. M. Baldwin, Jr.; the engineer and roadmaster, David Curtin, and the master mechanic, W. M. Brown. The vice-president, Mr. Goodrich, and the general manager, Mr. Hield, keep in very close touch with the work at the shops, and usually spend a portion of each day there, as all requisitions of the purchasing agent and all requisitions on the general storehouse must be approved by the manager. Two rooms on the second floor have recently been fitted up as offices for Messrs. Goodrich and Hield, so that the records, plans, etc., which they wish to keep at this building can be more conveniently arranged.

The heavy supplies are arranged in tiers of boxes and bins on the lower floor and the lighter supplies on the second floor. The third floor is used for storing patterns, of which the company has a complete line; the iron castings are about all that it has done outside, and for these it makes its own patterns.

The greater portion of the building joining the storehouse on the

Nov. 7 a full report of the year's operations will be sent to all the shareholders; meantime a few figures as of June 30 last may be of interest. When on that date a year ago the trustees organized they received either all or a controlling interest in the shares of thirty-one corporations, two of which were lighting companies. Since then four other companies have been acquired, including the South Shore & Boston and the Lowell & Suburban, whose acquisition you are asked to-day to approve."

He then referred to the consolidation into system of the various roads controlled by the company, and continuing said: "The results of the operation of the companies in which you are interested, excluding as before the Lowell & Suburban and the South Shore & Boston and also the New Bedford, Middleboro & Brockton, which company had not been acquired by the trustees at this time last year, are as follows, comparisons being made with the same period of the fiscal year, 1899:

	1900	1899	Increase	
Gross earnings......	$3,102,518	$2,809,464	$293,053	10.4%
Operating expenses..	2,132,679	2,087,898	44,781	2.14%

Operating ratio 68.75%.

"For the same period of nine months the net divisible income, after deducting all interest and other charges, has increased by $207,893. These figures do not fully represent in the improvement in the net divisible income, for the following reason: Believing it wise to provide a general fund as an insurance against losses caused by accidents to persons, the companies in which you are interested mutually established such a fund at the beginning of the present fiscal year, and each company now makes quarterly payments of a percentage of its gross earnings. The balance to the credit of this fund on June 30 was $117,000. Inasmuch as damage cases are seldom settled until some months after the accident occurs and inasmuch as only those accidents which happened since the first of last October are properly chargeable to this fund, the companies have been paying a double charge during the last nine months, because while they have been making the payments to the new fund they have been at the same time obliged to settle a number of claims antedating the establishment of that fund; therefore, in making a strict comparison of the results it would be proper to add the balance of this accident fund to the increase in net divisible income, making the total increase $324,893."

◆

The Utilization of Water Power for the Electric Railway System of Minneapolis and St. Paul *

BY EDWARD P. BURCH, CONSULTING ELECTRICAL ENGINEER

It is well known that within a few years a new dam has been constructed in this city across the Mississippi River just below St. Anthony Falls, that electricity has been generated by the power produced at the dam, and that the power has been utilized for the electric railway system of Minneapolis and St. Paul. It is the purpose of the lecture to review the engineering which has recently been accomplished in the utilization of this power.

THE MISSISSIPPI RIVER

The source of power is the upper Mississippi River, a peculiar stream; generally quiet and governable, yet at times of flood apparently beyond control. The flowage characteristics have been averaged year after year until we are certain of the general nature of the annual changes. By providing liberal margins we can predict with fair accuracy the amount of water which can be depended upon. These characteristics are given in Fig. 1, which shows the months of the year along the base line and the flowage in cubic feet per second vertically.

The flowage changes materially during the different seasons. During the first months of the year the lakes and great swamps in the northern part of our State freeze so solid that the flowage is greatly diminished. As warm weather comes on in April, the melting ice and snow invariably produces a flood, so that within a week of a spring break-up the volume may increase ten-fold. The summer flowage is several times greater than the winter flowage. There is commonly a second flood in September, after which the amount of water gradually decreases as cold weather comes on.

These characteristics of flowage are changing quite materially. The United States Government is constructing permanent dams at the outlets of the great swampy lakes on the upper Mississippi, thus forming immense reservoirs. The object of these reservoirs is to collect surplus water, principally in the spring and fall, which may be systematically released, especially in case of drought in midsummer or late in the fall. This storage capacity may ultimately become 100,000,000,000 cu. ft.

Not only is the intensity of the spring and fall floods thus reduced, but navigation is facilitated and a more equitable distribution of water for power results. As this immense reservoir system grows, the curves of flowage become more nearly flat. At present the general mean minimum flowage in February is about 2500 cu. ft. per second, the spring flood commonly reaches 15,000 cu. ft. per second, and the summer flowage at least 6000 cu. ft. per second. By utilizing local storage the amount of power available may be increased 10 per cent at times of heavy demand.

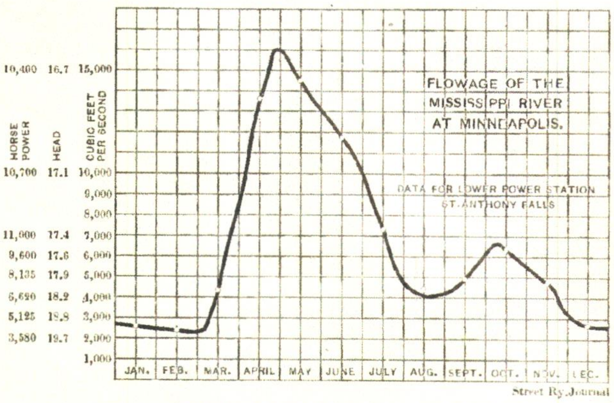


FIG. 1.—FLOWAGE OF RIVER AT MINNEAPOLIS

ST. ANTHONY FALLS

Within the limits of the Twin Cities the Mississippi has a fall of over 110 ft. Just above the city limits there is what is known as Coon Rapids, where there is a fall of 20 ft. This power has not been developed. Between the Minneapolis Western Railroad bridge at Eleventh Avenue South in Minneapolis, and Fort Snelling bridge in St. Paul, there is a fall of 40 ft., along which the government has laid out and is now constructing locks and dams.

The main St. Anthony Falls, with a fall of 50 ft., have been utilized for forty years. With normal summer flowage, 6000 cu. ft. per second, about 25,000 mechanical hp are available and are used, largely for flour manufacturing.

CONSTRUCTION OF THE NEW DAM

St. Anthony Rapids, just below the main falls, has been developed within the last few years. The construction of a dam below what was formerly known as the "rapids" (now known as the lower power) had been in the minds of capitalists and engineers for many years. With normal summer flowage it was estimated that a dam giving a 20-ft. fall could develop 10,000 hp.

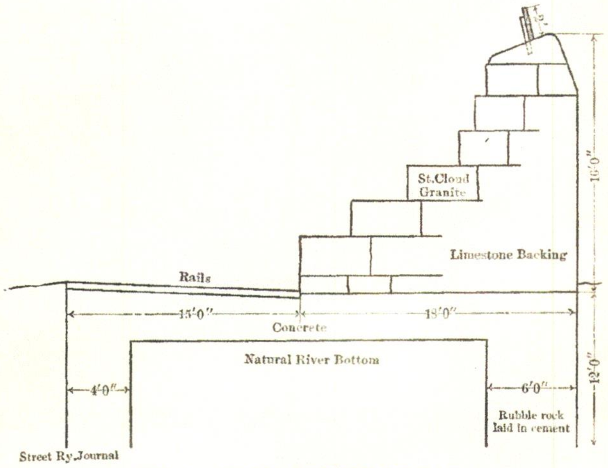


FIG. 2.—CROSS SECTION OF DAM

The riparian owners, St. Anthony Falls Water Power Company, having procured ample English capital, their hydraulic engineer, William de la Barre, started the construction of this new Lower Dam at St. Anthony Falls in May, 1895. The work was finished and turned over to an operating company Jan. 1, 1898. Fig. 2 shows a map of the upper and lower power at St. Anthony Falls.

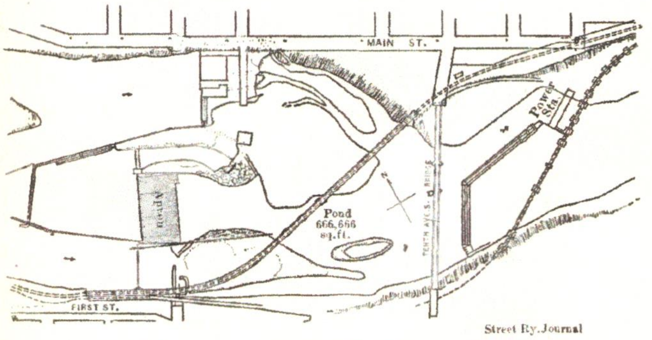
In the construction of the lower power the general plan carried out was to build a dam directly across about two-thirds of the main river, then making an obtuse angle, run diagonally across toward the east bank to a power station at the foot of the canal or

---

* Paper read before the Northwestern Railway Club, April 10.

head race thus formed. This plan of construction was a most advantageous one. The walls of the canal were built first, and on the dry east bank the great waste gates were installed and the power station foundations were completed, all during the first season.

The second year, 1896, the water of the entire river was deflected from its old bed into the new canal and sent through the waste gates and also under the power station. A coffer-dam was then built across the old bed of the river. The main dam, located 2000 ft. below the upper falls was then started, and was nearly completed during the second year. At the beginning of the third year, the spring of 1897, a most disastrous flood, amounting to 60,000 cu. ft. per second, swept away the coping and other portions of this section. In repairing this break, a rock-filled, timber-framed approach, lined with steel plate was built in front of this section of the main dam, in order to ease the battering which piers, logs and ice give the structure.

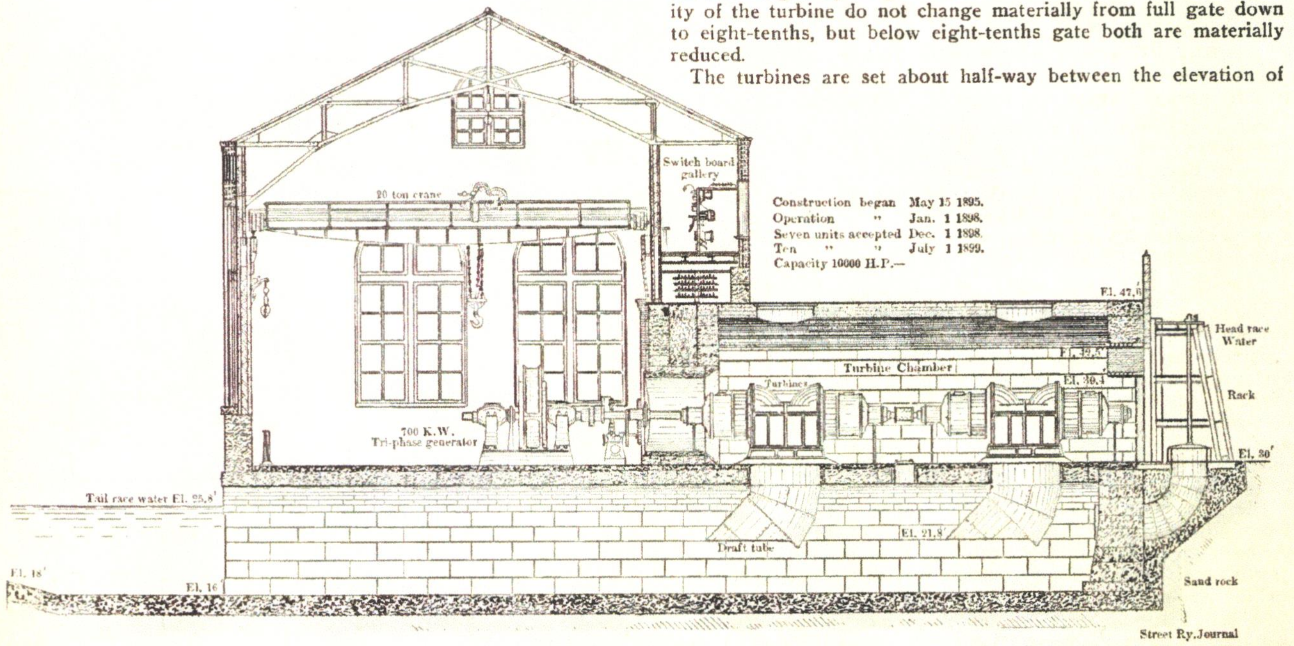


Street Ry. Journal

FIG. 3.—MAP OF UPPER AND LOWER DAM

Examining the plan as a whole, note that the great length of the dam allows the water to fall over a very long crest of the dam during a flood, thus lessening the wear and tear of the fall by distributing it over a greater surface. A cross-section of the main dam is shown in Fig. 3.

The dams are 1085 ft. long. The height of the dams is from 14 ft. to 16 ft. above the river bed. Below the superstructure there is a 3-ft. base of concrete, 33 ft. wide. This base is especially well reinforced by a rubble rock and concrete dyke construction in the sand rock below the crest line of the dam and again at the toe of the dam. This will prevent undermining. The face of the dam is perpendicular. The down-stream side is so shaped or sloped as to ease the momentum of the water and discharge it horizontally, thus preventing an undertow which might prove fatal to the structure.



Street Ry. Journal

FIG. 4.—CROSS SECTION THROUGH LOWER STATION

The main structure is of limestone from the quarries on the east bank of the river. The facings are of St. Cloud granite. The coping is lined with skeleton steel plate and the base of the dam with steel rails in 15-ft. lengths laid side by side in cement. These rails are laid with their outer ends 6 ins. higher than the end next to the dam—thus a pool of water is formed which acts as a cushion and protects the concrete work from erosion.

THE STATION

The power station forms 200 ft. of the dam. Inside, it is one large room 250 ft. long, from 45 ft. to 55 ft. wide, and 50 ft. high inside. The station is heated by electric heaters; a 20-ton traveling crane is provided.

The station, shown in section, Fig. 4, is built on solid sand rock. First, a concrete base, the present tail-race floor and foundation for tail-race arches, was laid 2 ft. thick under the power station. The top of ten tail-race arches forms the floor or substructure of the station. The turbine chambers and the tail-race arches are spaced horizontally 20 ft. apart from center to center. Large sulice gates allow a by-pass for the water in front of the chambers to the race below. In front of the entrance to the turbine chambers, a structural steel framework is formed to support the racks—a steel screen of ¼ in. iron, 3½ ins. wide and spaced 1 1-3 ins. apart, to prevent the entrance of floating logs, bark and ice.

THE TURBINES

In the water chambers ten large turbine units were installed. The capacity of each unit is approximately 1150 hp on 20-ft. acting head at 130 r. p. m. The capacity of the turbines varies as the square root of the cube of the acting head. There is one speed on any given head at which they run at highest economy, this speed varying with the square root of the head. Thus, on 17½-ft. head the horse power would be

$$1150 \times \sqrt{\left(\frac{17.5}{20.0}\right)^3} \text{ or } 940,$$

and the most economical speed 121.6. If a higher or lower speed is used on 17½-ft. head, the horse power capacity of the turbine is materially less. At 190 r. p. m. the horse power capacity is naught.

The object of the turbine governor is to provide a speed of 130 revolutions, given any head and any load which may be on the generator. This is done by a centrifugal governor which controls the turbine gate opening or water inlet. The efficiency and capacity of the turbine do not change materially from full gate down to eight-tenths, but below eight-tenths gate both are materially reduced.

The turbines are set about half-way between the elevation of water in the head and tail-race. The pressure above the turbine runner and the suction from the draught tubes together form the head on the turbine. Should the normal elevation of water in the head race increase 2 ft. during a common spring or fall flood the normal elevation of water in the tail-race would make a corresponding increase in elevation of 5 ft., or even above the floor of the power station should the flowage amount to 30,000 cu. ft. per second. The result is that during a flood there is a smaller quantity of water per turbine and a much lower acting head. Therefore, the capacity of each unit and of the power station is always the least when the quantity of water in the river is greatest and vice versa. Floods as well as droughts are thus undesirable.

The acting head on the turbines is nearly 1 ft. less than the fall of water produced by the dam. This is due to friction losses past booms, through racks, eddies in the turbine chamber, and the piling up of the water discharged by the draft tubes.

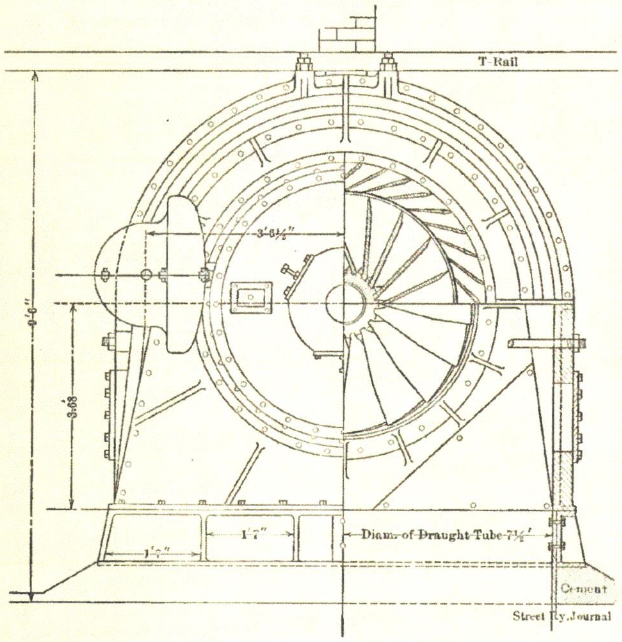


FIG. 5.—CROSS SECTION OF 46-IN. TURBINE

Drawings of the turbines are given in Figs. 5, 6 and 7.

Each 1150-hp turbine is directly connected to a 1000-hp electric generator, the turbine shaft passing through a water-tight flume cover into the generating room. Ten 1000-hp and two 150-hp generators have been installed. The generators are of two classes or types, well adapted to the work of distribution to be referred to later. The power, after being converted into electricity, is sent to the switchboard in the gallery, where it may be controlled and distributed.†

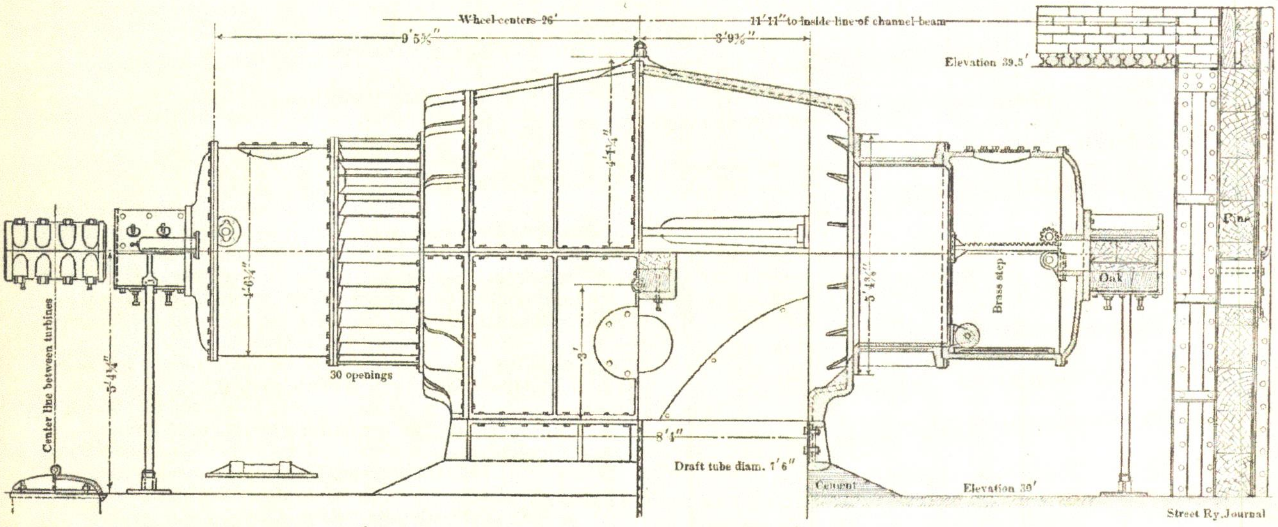


FIG. 6.—SIDE ELEVATION OF FRONT 46-IN. TURBINE FLUME AND CASE

THE TWIN CITY RAPID TRANSIT COMPANY'S ELECTRIC RAILWAY SYSTEM

The power service is now ready. One of the corporations to whom propositions were sent on the sale of the power, was the Twin City Rapid Transit Company. This company has an electric railway franchise, owns and operates the entire electric railway system of Minneapolis and St. Paul. It has 240 miles of track in service. Its annual revenue is over $2,500,000, coming nickel by nickel from 50,000,000 passengers. Its annual car mileage is 13,000,000. The maximum number of cars in ordinary daily service is about 400; in maximum service, 550.

From 1891 to 1897 it had four steam plants with a capacity of 11,500 hp, equipped with modern boilers and engines and fairly modern generators. These plants were distributed as shown.

By a consolidation into one large power station, many savings due to the cheap water power, decreased labor, repair expenses and distribution losses were apparent.

A forty-year lease of all the power produced by the dam was effected by the railway company about Jan. 1, 1897. The choice of generating machinery, transmission and distribution plans and equipment was left to the railway company.

TRANSMISSION AND DISTRIBUTION

Without detailing the investigations made by the company, we can say briefly that exhaustive study was made of the most modern electric plants in the country, of most improved methods of transmitting and distributing large blocks of power over long distances.

Given 10,000 hp at the dam, the problem was to convert this power into electrical energy and distribute it to 500 cars scattered over two cities. About sixty of the heavier cars were within a mile of the station. The generation and transmission of 2000 hp for these sixty cars was planned and carried out by using low voltage direct current. This low voltage, 600 volts, is adapted only for short transmissions. It was necessary to send 3000 hp to No. 1 steam station, now known as a sub-station. The distance from the water power station to this sub-station is 1½ miles. For this transmission it was necessary to employ alternating currents and to use a pressure six times as high as that used for the short and ordinary transmission just referred to.

Similarly, 100 hp is sent to No. 2 steam station, now a sub-station. For St. Paul 2000 hp was sent to No. 3 sub-station, formerly the old steam plant, and 2000 to sub-station No. 4, a building and location especially selected for the purpose.

Alternating current apparatus is necessary for economical and structural reasons when we will transmit large blocks of power over long distances. High pressures are necessary in order to reduce the first cost of apparatus and in order to decrease transmission losses.

If you were going to transmit a million gallons of water 1 mile per day, a small-sized pipe and moderate pressure, 60 lbs. per square inch, would be used. If you were to transmit a greater quantity of water and several miles, you *could* increase the size of the main, reducing the friction loss materially. A better plan, however, one involving less first cost, might be to use the small pipe and raise the pressure to, say 1200 lbs., as oil is transmitted in Ohio.

Similarly, in transmitting large blocks of electric power over long distances, good engineering calls for small conductors and high pressure.

The two transmissions to St. Paul were especially long, 7 and 9 miles. It was necessary to use 12,000 volts, an extraordinarily high pressure, in order that the cost of cables and the losses in transmission might be reduced. Twelve thousand volts was the highest pressure heretofore carried for heavy power distribution in underground cables, and many were the prophecies of failure. One cable, 2 ins. in diameter, was used for each 2000 hp transmitted. Each cable contains three wires, each .4 in. in diameter, separated and insulated from each other and from a lead sheath by common manilla paper impregnated with resin oil, linseed oil and other insulating compounds. The cable is drawn in cement conduit ducts 3 ins. in diameter. These ducts are protected by concrete and are laid about 3 ft. below the roadbed. Manholes are located every 500 ft. for the purpose of drawing the cables in the duct, making cable splices and for inspection and repairs. Drawings of cables and splices are reproduced in Fig. 8.

---

† Additional notes on station and other equipments will be found in *American Electrician*, May, 1898; *Street Railway Review*, February, 1899; STREET RAILWAY JOURNAL, June, 1897; *The Electrical World*, Oct. 8, 1898.

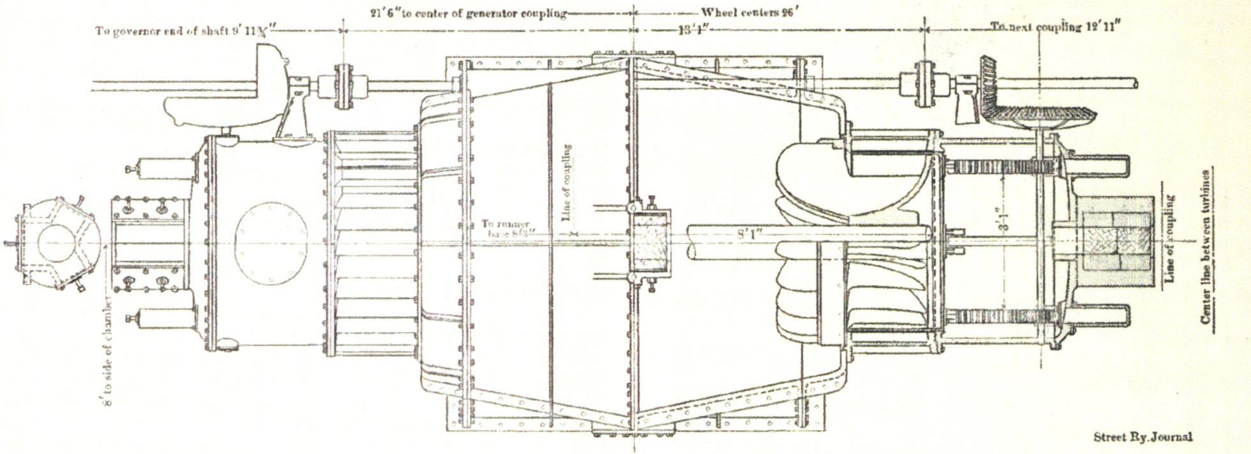


FIG. 7.—REAR 46-IN. TURBINE FLUME AND CASE

SUMMARY

Reviewing the complete cycle, let us start over again with the water which formerly tumbled down the rapids below St. Anthony Falls. It has been dammed, a pond formed and a fall of 18 ft. produced. The falling water, in passing through the turbines, develops 10,000 hp, which is converted into electric power by the generator attached to the turbine. Direct current of low pressure is provided by two of the 1000-hp generators, while alternating current of moderately high pressure is generated by the remaining eight generators. All the electric power is first carried to a switchboard in the gallery. The operating electrician can start the generation of current, vary the amount, and read from the meters the amount developed. By means of switches, varying amounts are sent to the different sub-stations to meet the changing conditions of load and service. The low voltage direct currents are sent to the nearer lines, especially for the heavy interurban service. Medium pressure alternating currents, at 3500 volts, are sent to the Minneapolis sub-stations, and the extremely high pressures, 12,000 volts, are sent to the St. Paul sub-stations.

It may be interesting to state that the transmission of 2000 hp over 9 miles to the further St. Paul sub-station, at 12,000 volts pressure, is accomplished with a cable loss of but 5 per cent of the power so transmitted.

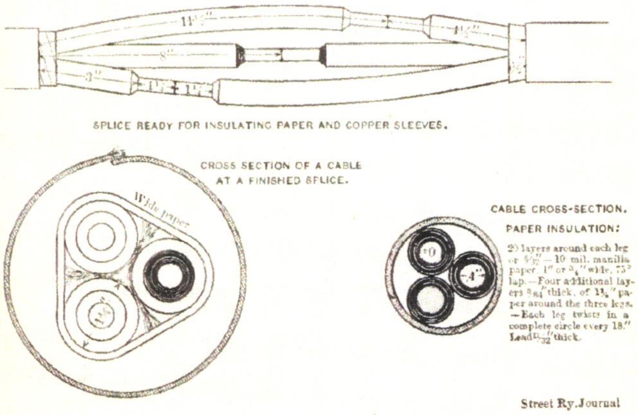

11¼"
4½"
8"
3"
1½"
1½"
SPLICE READY FOR INSULATING PAPER AND COPPER SLEEVES.
CROSS SECTION OF A CABLE AT A FINISHED SPLICE.
Wide paper
CABLE CROSS-SECTION.
PAPER INSULATION:
20 layers around each leg or 4/32" — 10 mil. manilla paper, 1" or ¾" wide, 75° lap.—Four additional layers 3/64" thick, of 1½" paper around the three legs. —Each leg twists in a complete circle every 18." Lead 11/32" thick.
.4"
Street Ry. Journal

FIG. 8.—CABLE SPLICE FOR THREE-PHASE 1200-VOLT CABLE

At the sub-station the alternating current is reduced in pressure and converted into direct current, after which the sub-station operator sends the power through his local distributing switchboard.

An attendant is required to supervise the transforming and converting apparatus at the sub-station and to care for the low tension railway distributing switchboards. Copper feeders distribute the power from these switchboards to the different trolley sections. Over 1,200,000 lbs. of copper are required for these local distributions. The current at the car is under the control of the motorman, who uses it for the motors on the trucks beneath the cars.

In this railway system there are three interurban lines; the longest, 22 miles long, between St. Paul and Stillwater, has on the car equipment air brakes, air whistles and arc-lamp head lights. It makes 44 miles per hour, maximum speed; has a schedule of 22 miles per hour. Each car has a telephone used for dispatching cars. Long 10 per cent grades are mounted. All interurban cars are double truck, 44 ft. long, weigh from 18 to 22 tons, and seat fifty-two passengers.

The efficiency of the whole power system is very low. There is a 5 per cent loss due to booms, racks, eddies, etc., near the station, so that we may say the efficiency of the falls is 95 per cent.

	Maximum per cent	Ordinarily per cent
The efficiency of the turbines	80	78
The efficiency of the generators	95	94
The efficiency of the station distribution	92	90
The efficiency of the conversion to direct current	94	91
The efficiency of the local distribution	90	92
The efficiency of the railway motors	80	70

So that of the 10,000 hp developed by the turbines, the railway motors could not get 5900 mechanical horse-power at highest efficiency and not over 5000 hp during ordinary operation. Moreover, 50 per cent of all the power delivered to the motors is spent in acceleration, only to be destroyed in the same block by braking. The motor tractive effort is very high, 25 lbs. per ton, compared with 5 lbs. per ton in steam railroad service.

The cost of the entire power service on this system is but 14 per cent of the total cost of operation of the system.

In closing the lecture, let us consider for a minute the application of an entirely similar system for *steam* railroad service.

The amount of the steam railroad business in this country is not large. The Twin City Rapid Transit Company's passenger service was $2,500,000 last year, while the entire steam passenger service of the country during 1899 is given by one authority as $330,000,000. A far greater problem for the engineer's consideration is the freight business, amounting to $880,000,000 per annum.

The power might be generated by steam or gas engines if water power was not available, but the general plan of the station, the polyphase generators, the transmission, the sub-station and utilization could be quite similar to the system above described.

Many of the steam railroad systems in and radiating from the Twin Cities present quite favorable conditions for the substitution of electricity for steam. This is particularly true where the public appreciates and will use better transportation facilities. By better, we mean faster service, lower fares and more frequent train service. Where these conditions can be worked out, the motive power can be changed from steam to electricity with a resultant decrease in operating expense per passenger carried.

The heavy service on lines in thickly settled districts and between our cities and towns will adopt electricity first, after which the main trunk lines, with their light passenger service, and later the heavy freight trains will follow, when the management finds electric service is satisfactory as a motive power and in financial results.

The first few years of the coming century will see rapid progress along these lines. Some of the members of the Railway Club will be found engaged in this development.

DISCUSSION

Prof. G. D. Shepardson—Mr. President, there are about three points that I could speak of in which the Twin City Rapid Transit Company has been one of the pioneers.

One is the general adoption of electricity for power. I believe that when the horse cars were finally dropped in the Twin Cities this was the largest electric street railway system in the world. Since that time some of the Eastern cities have exceeded these cities in the number of cars and number of miles of track. This system also I believe is one of the first of the interurban roads, that is, in connecting neighboring cities. Nowadays it is nothing at all uncommon to find electric railway lines connecting neighboring cities. I think at present the longest continuous line in operation is one between Detroit and Ann Arbor, Mich., where there are 40 miles in one stretch. But at the time the interurban road was put in between Minneapolis and St. Paul I believe that was the longest electric railway line in the world.

The other point in which the Twin City Rapid Transit Company has been a pioneer is in the transmission of power at a high pressure for a considerable distance under ground. The speaker of the evening mentioned to-night the difficulties which were expected to arise, but I believe this is the first case where energy has been transmitted so long a distance, at such a high pressure, under ground.

It is a point of considerable interest to know that the telephone people were terribly disturbed lest the high pressure alternating current which was being sent under ground should be a disturbing factor on their telephone lines. This was the only place in the country where they could examine the matter, and the telephone engineers came here from Boston, New York and other Eastern places to examine the system.

So, in at least three particulars, the Twin City Rapid Transit Company has been a pioneer.

I suppose I might add a fourth way, which is not, perhaps, so favorable to railway people, and that is that the vigorous competition between the trolley roads and the steam roads had its effect, and the short line trains were gradually abandoned. That experience has been duplicated in other places since, but I believe that this is the first place where the trolley cars successfully competed with the short line steam roads.

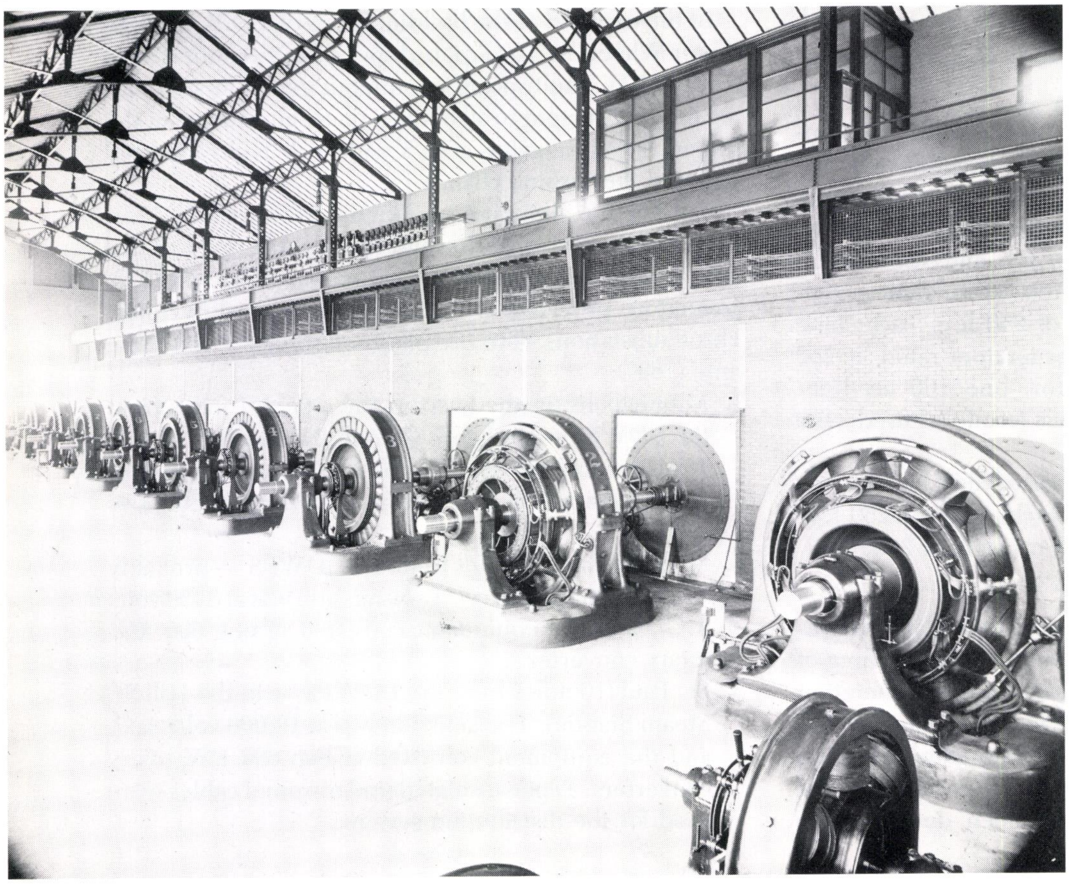
It is interesting to notice that the steam railroad people have adopted the very means which have taken from them a great deal of business, and in quite a number of cases the steam roads have adopted the practice of trolley service on their short lines, with a marked diminution in running expenses and a marked increase in profits. As the speaker said, when we increase the frequency of the service we increase the amount of travel.

The Twin City Rapid Transit Company has been one of the pioneers in other improvements than those already mentioned. About the first instance where street railway feed wires were placed under ground was on Nicollet and First Avenue South in Minneapolis. The "jumper system" of connecting the different sections of the conductors by means of fuses around the circuit breakers was worked out in Minneapolis, the idea having been proposed, I believe, by Mr. Burch; this plan has since been adopted by many large roads, since it reduces the fluctuations of load on the individual feeders as well as upon the power house; it maintains a better pressure upon the lines and thus enables a higher speed to be secured; it reduces trouble at the switchboard and at the power house as a result of the less fluctuation of current, and it is of especial value in case of congested traffic at unusual points. The series-parallel controller, in universal use at present, is the result of the experience of many roads and many men, and it is a matter of some pride that two members of this club, Mr. Burch and Mr. F. W. Springer, of the University of Minnesota, are entitled to the credit for designing the controller which has been in use for a number of years on the Twin City lines and which was practically the first one that proved to be a really successful device; this effected a saving of fully 20 per cent of the power formerly required for operating the cars. I may be pardoned for mentioning in this connection that I had the honor of being the first to discover the true explanation of the curious phenomenon known as "bucking," in which a car suddenly and violently stops as if by a collision; this had been previously considered as a mysterious visitation of Providence that was inexplicable except in a very few cases; by careful examination of a number of cases occurring in this State, the speaker finally located the invariable conditions which caused the trouble and was able to demonstrate a method for making such accident impossible. The safety gates, now so common, were first applied to street cars in Minneapolis, although somewhat similar to those on the elevated roads.

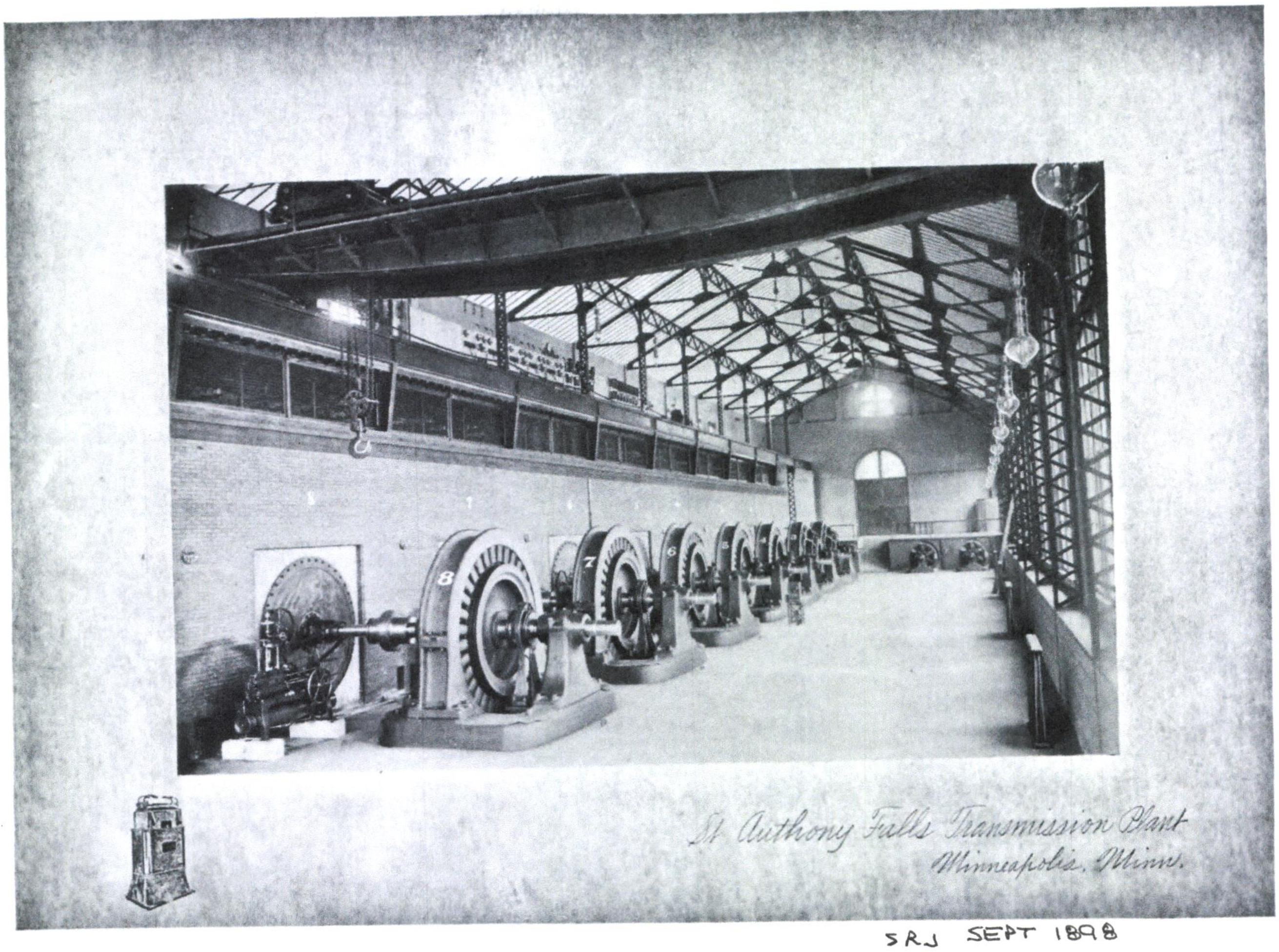
Secretary Foque—Mr. Burch spoke of the generator shaft being extended 2 ft. beyond the bearings, the idea being to eventually put on a vertical direct-connected engine. Is that in case of the failure of the water power?

Mr. Burch—When the electric railway traffic and load grow beyond the capacity of the river in winter, reserve engine capacity is needed. The original plan was to have this equipment at the station. It is not probable that this plan for reserve or for additional capacity will be carried out in this way.

◆

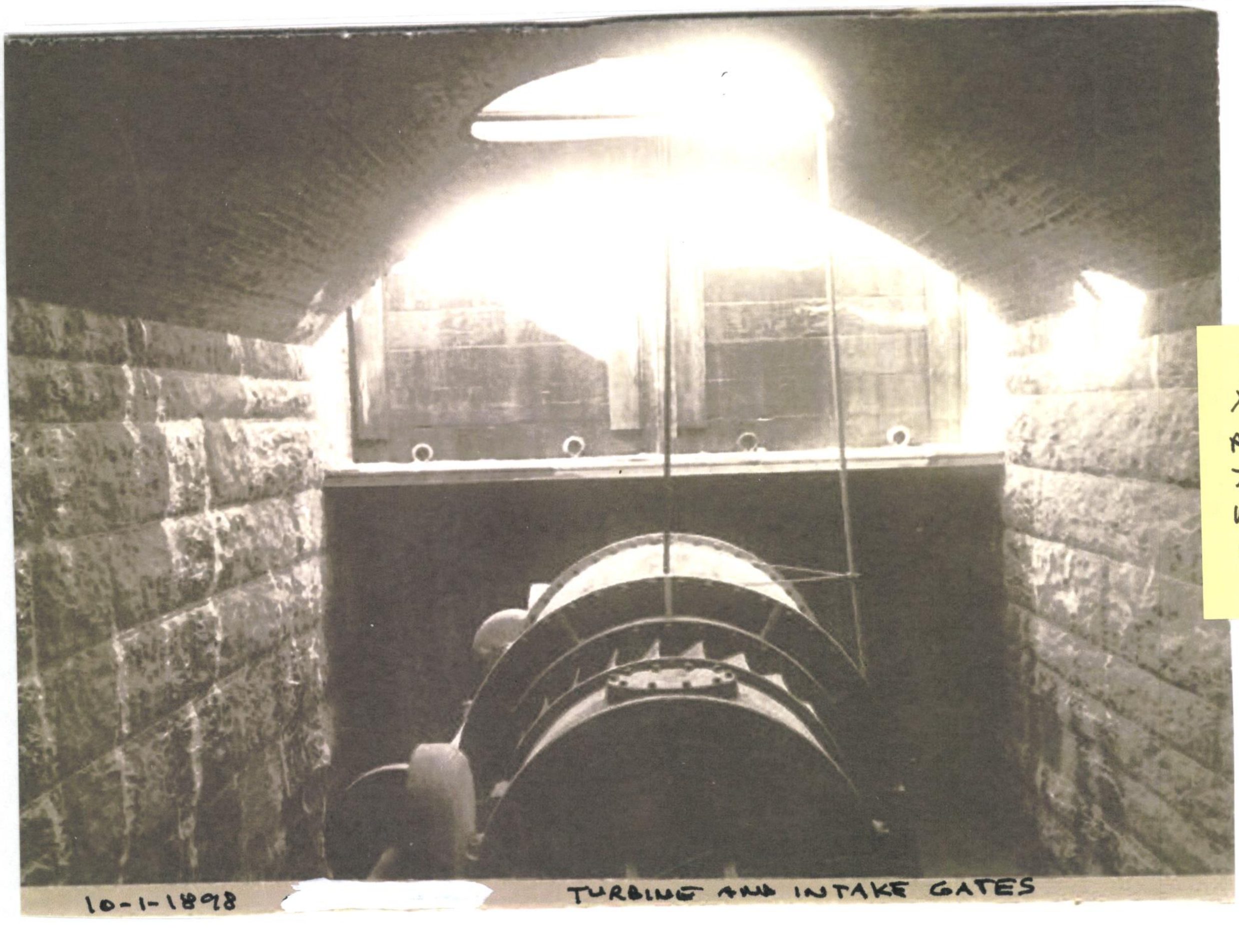


AVERY® PV119



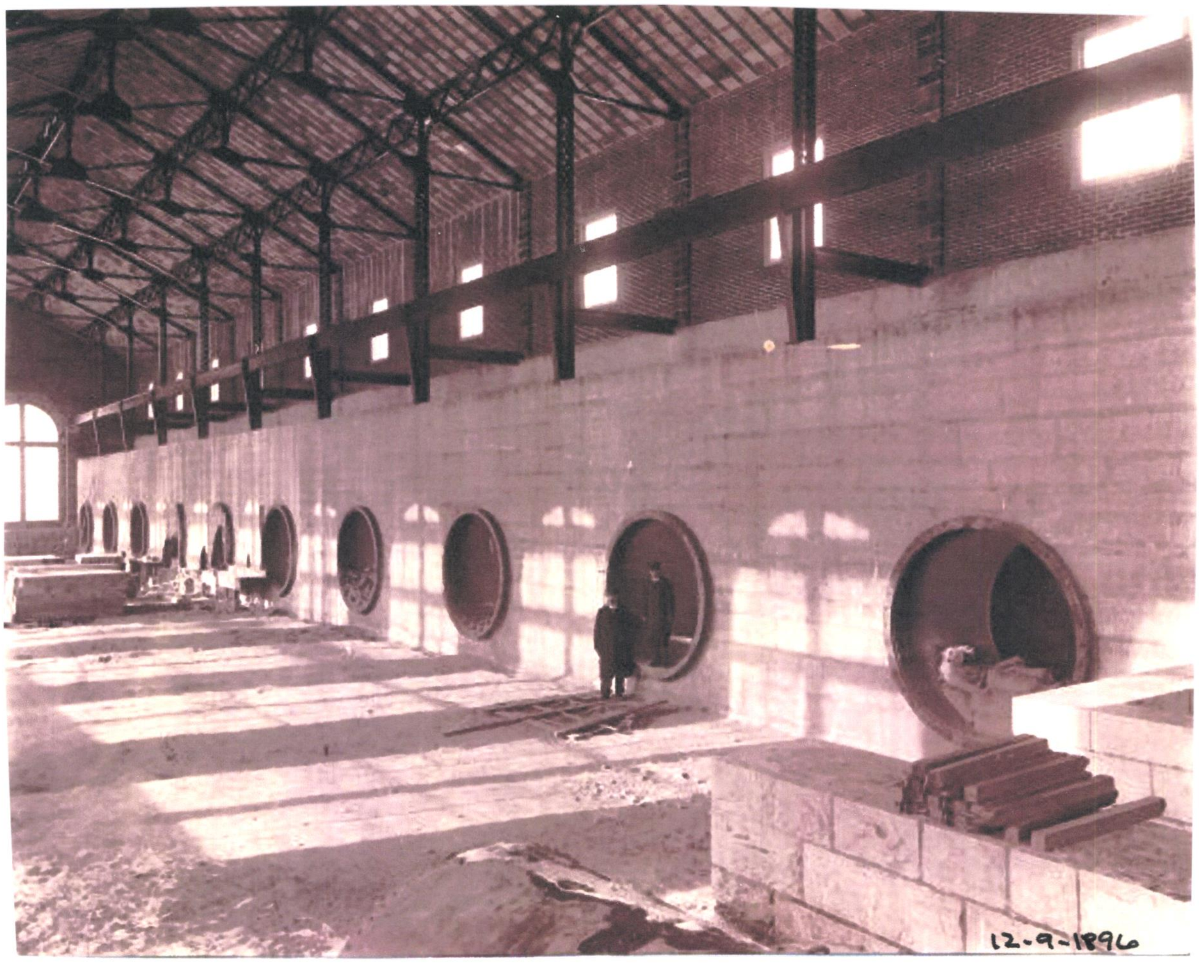
St Anthony Falls Transmission Plant
Minneapolis, Minn.

SRJ SEPT 1898

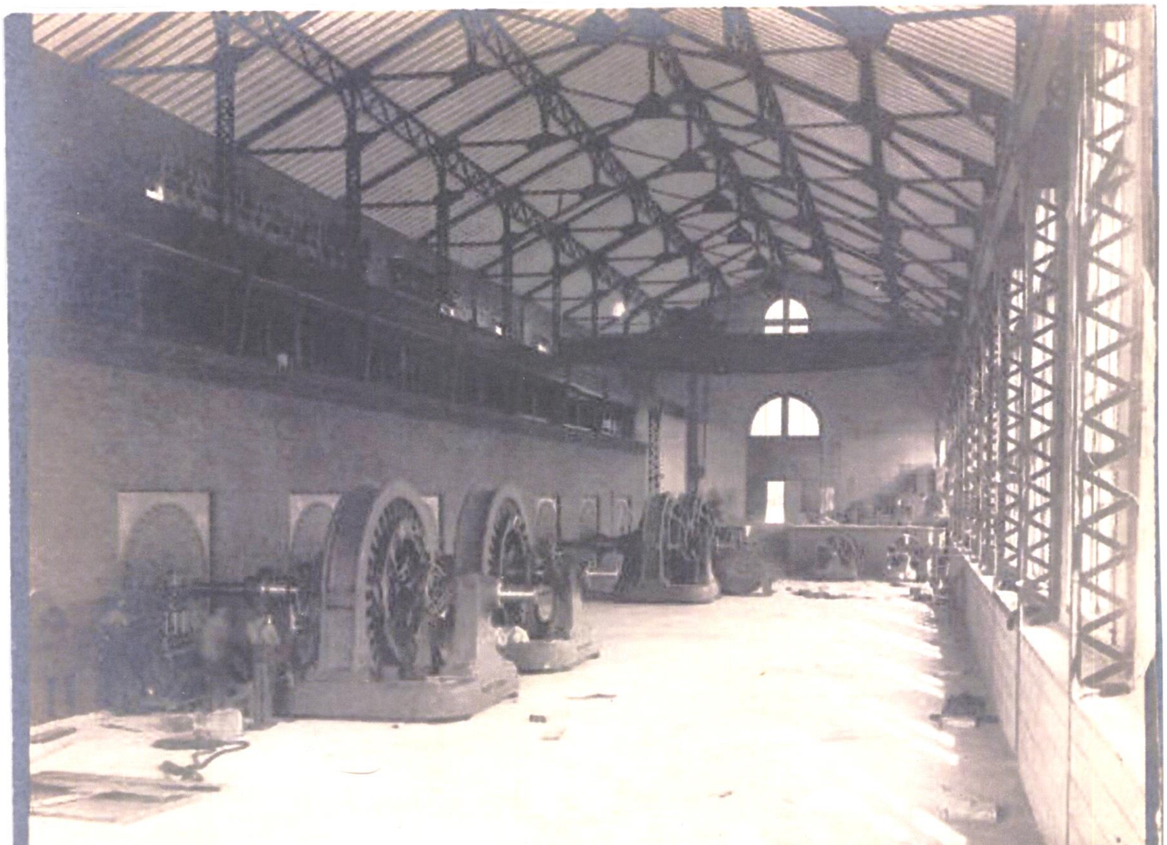


10-1-1898 TURBINE AND INTAKE GATES

Lower Dam Water Power Station construction photographs are from the St. Anthony Falls WaterPower Company Collection

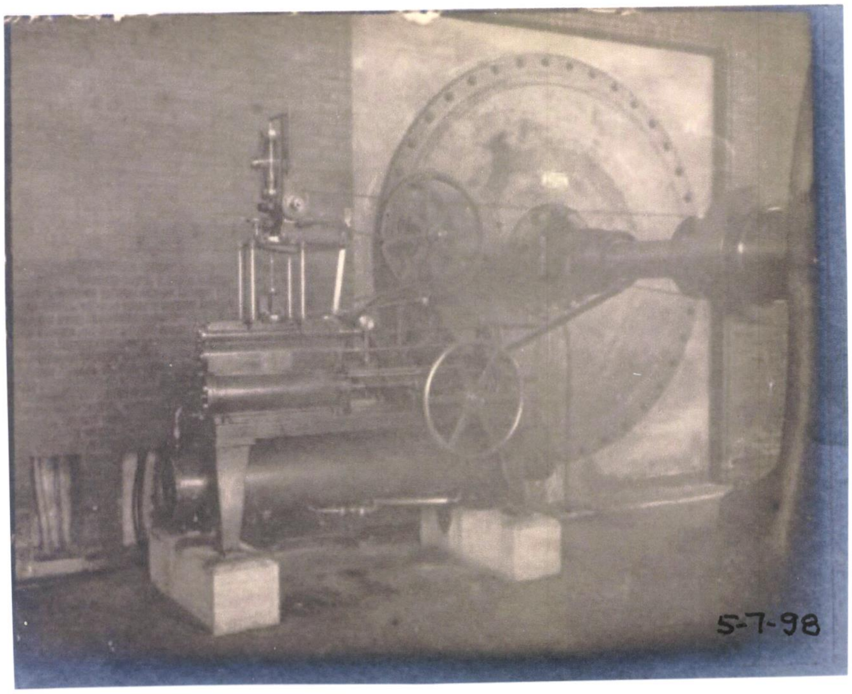


12-9-1896

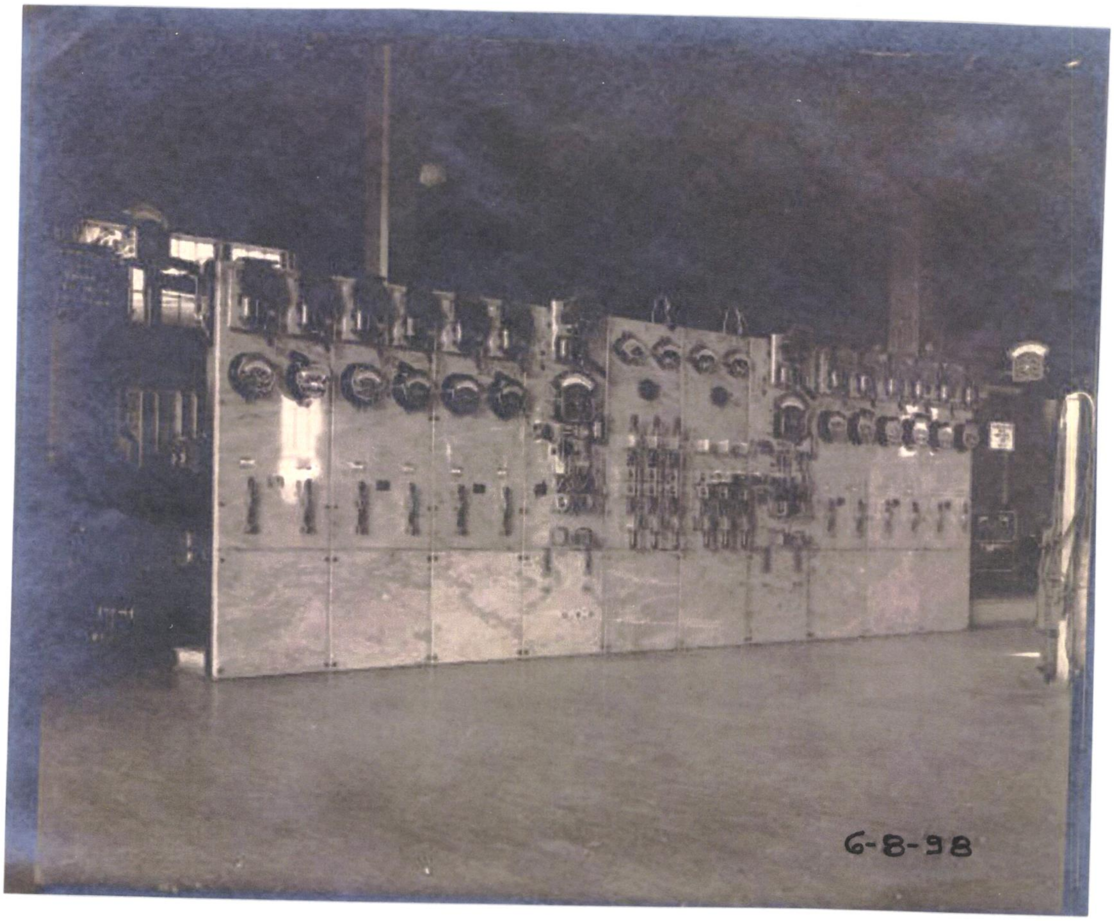


9-25-97

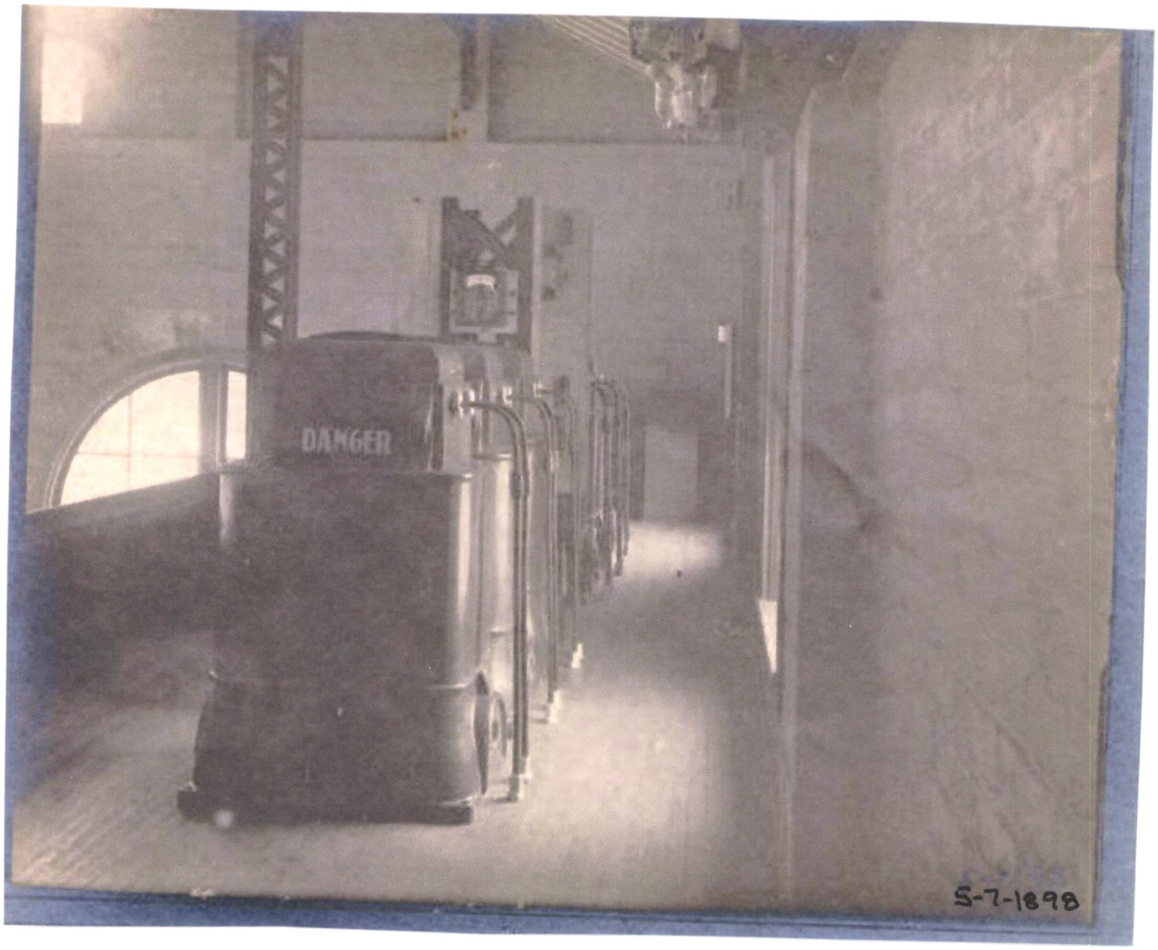
9-25-1897


5-7-98

5-16-98

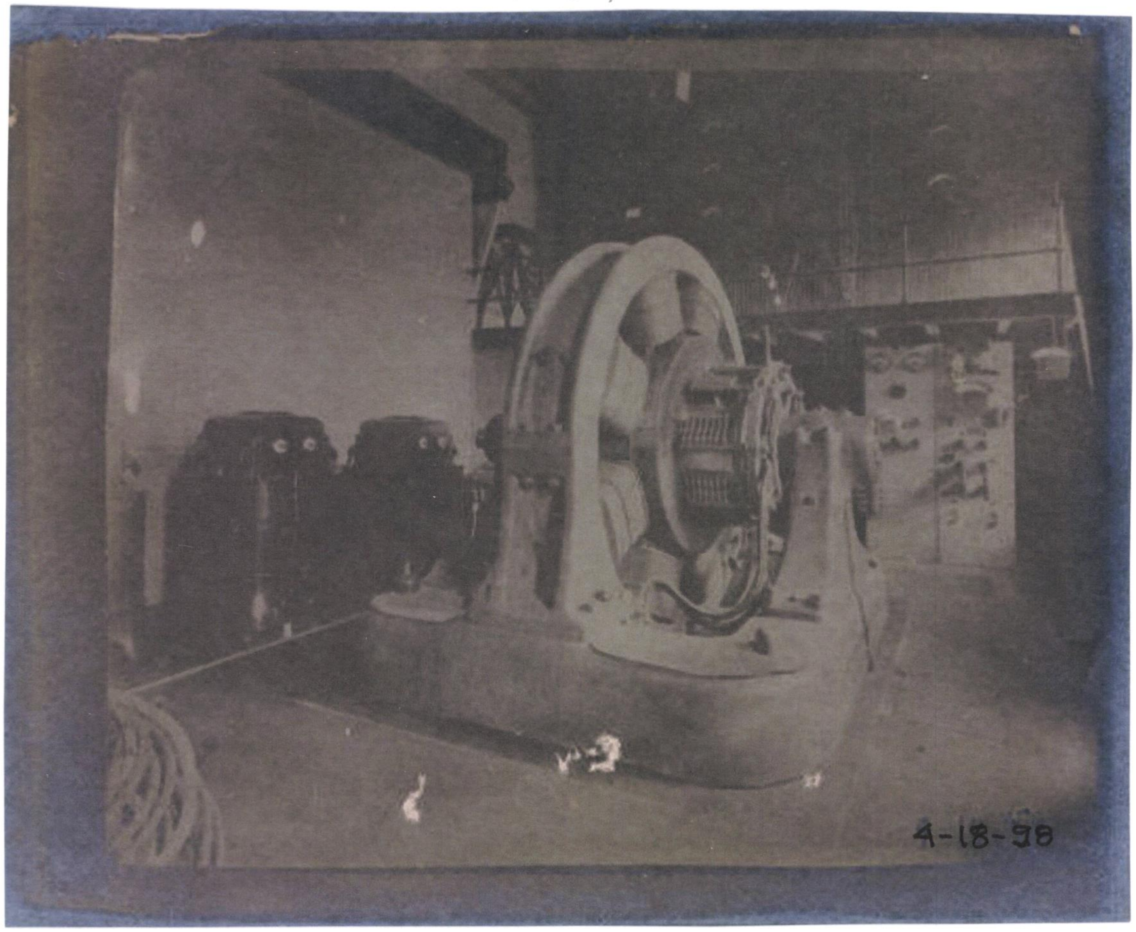


6-8-98

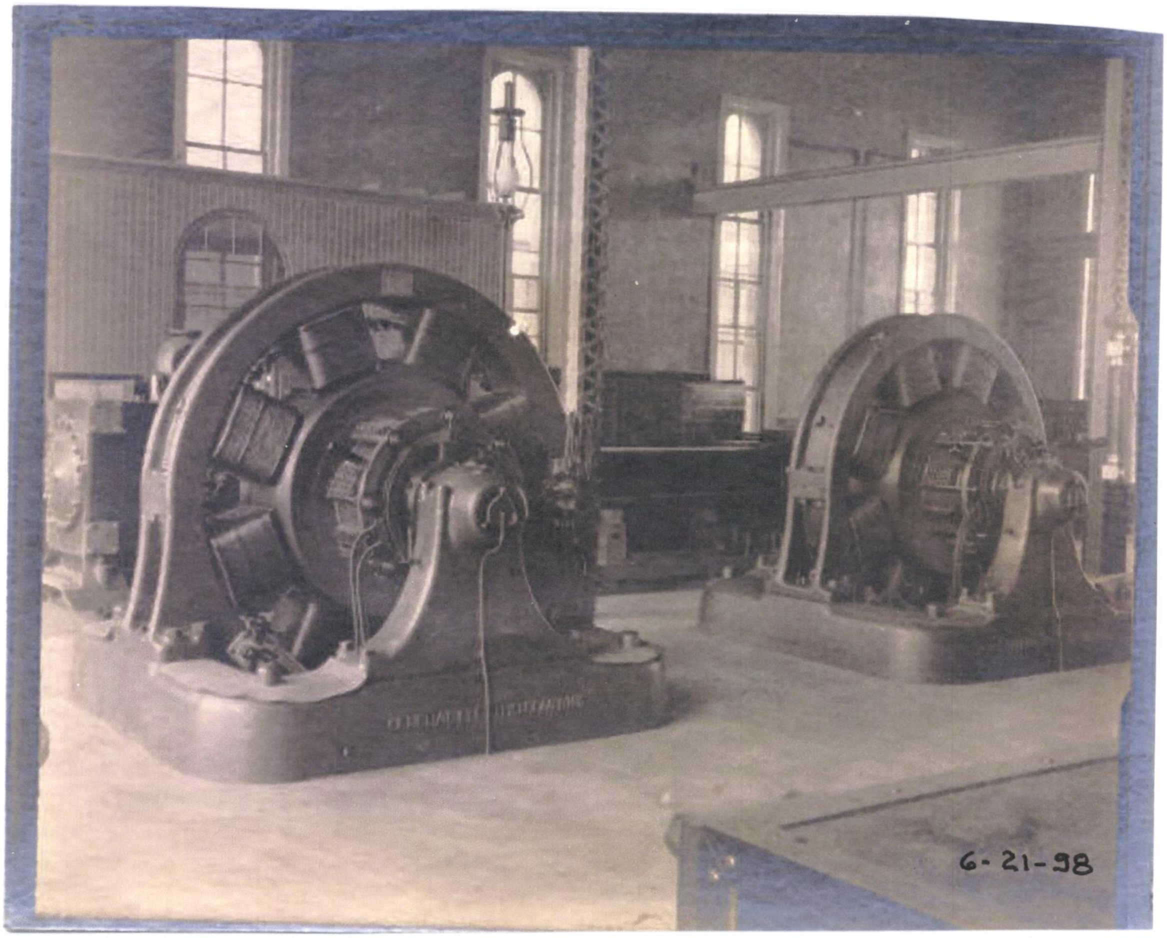


5-7-1898

SUBSTATION ?

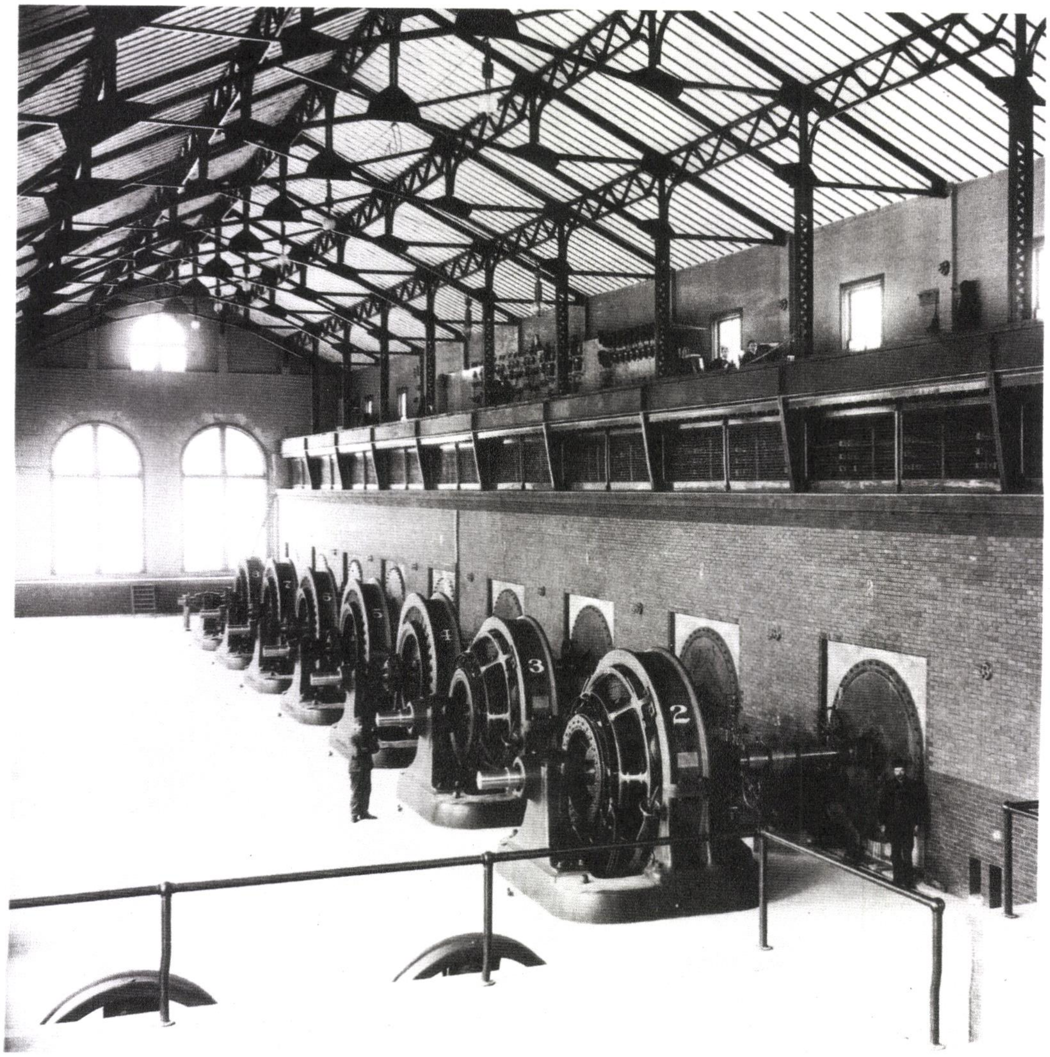


4-18-98

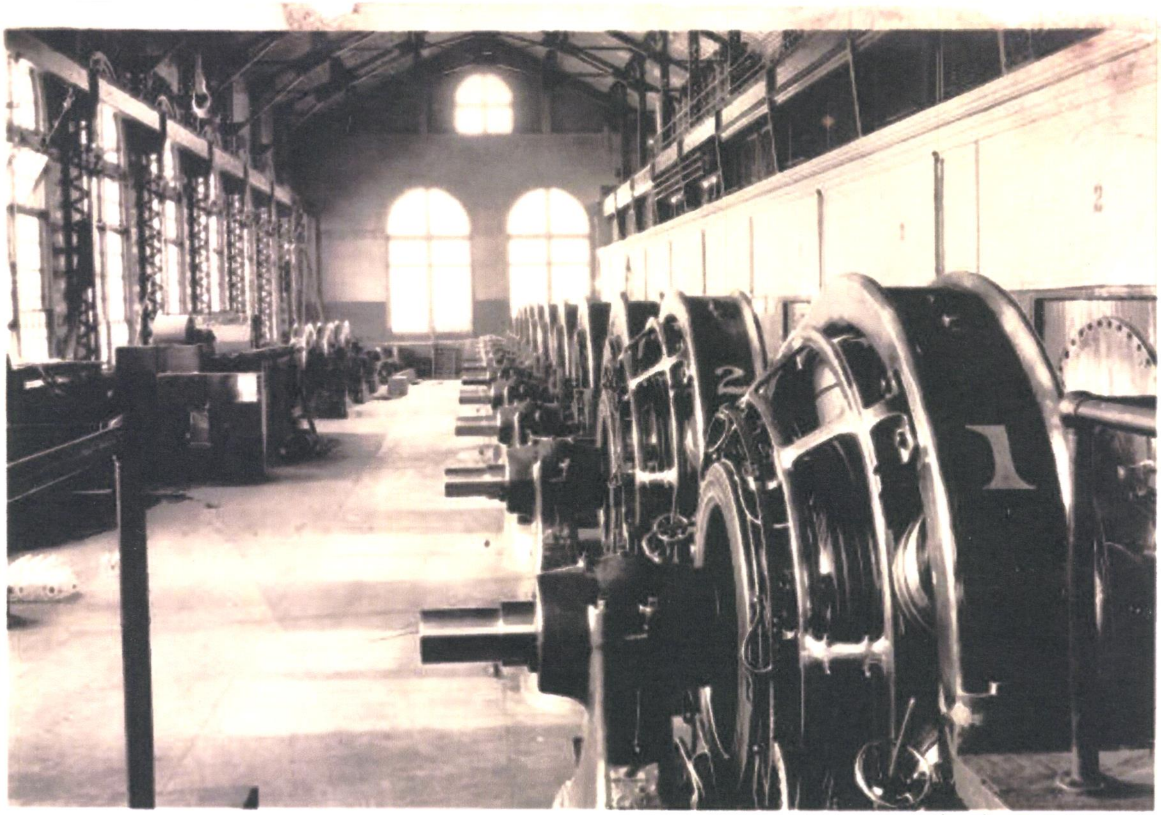


6-21-98

1903



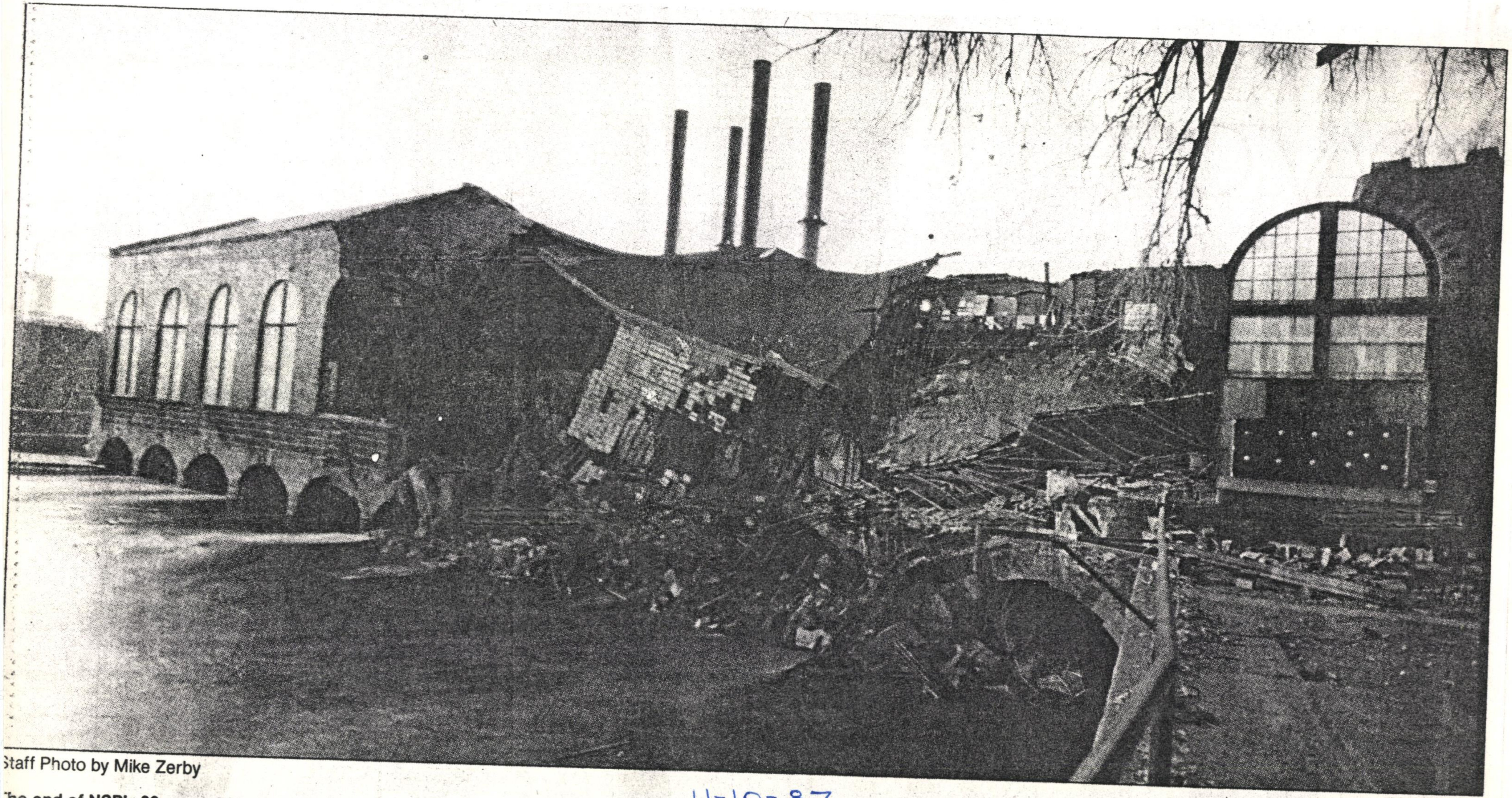
The Lower Dam Hydro Plant, strikingly modern even in this 1895 view, powered streetcars until the 1950s, when it became part of Northern States Power. The building and dam washed away in 1987 when the sandstone layer beneath it was scoured out.



4-1925

Sinkhole underneath
limestone foundation.

Total loss. Demolished
and removed



Staff Photo by Mike Zerby

11-10-87

The end of NSP's 90-year-old hydro plant at Lower St. Anthony Falls came at 4:15 p.m. Tuesday when the main floor of the old powerhouse and most of its roof collapsed.

After 90 years, river's power claims NSP plant

y Dean Rebuffoni

1987

DETAIL OF POWER PLANT SUSPENSE ACC'T

FOLIO 345 CONSTRUCTION LEDGER

1 9 0 1 --- 1 9 1 0

		DR.	CR.
O. 4335	Dismantle and remove equipment at 3d Ave. North & Hill St. Power Plant	6,944.21	
	Sale of belting from Wildwood		300.90
	" " lumber		9.01
	" " pipe & fittings to Nat'l Steel Co.		127.58
	" " 2 A. C. engines from 3d Ave. No. to Allis Chalmers		8,000.00
	" of 2 engines from Hill St.		3,500.00
	" " 13 generators to St. P. S. I. & M. Co.		4,650.00
	" of 1 car brick		25.00
	" " engines and pulleys from Hill St. to North Amer. Lead Co.		4,470.19
	" of scrap iron, pipe, fittings, etc.		246.29
Transferred Balance to New Power Folio 1,000		14,384.76	
		21,328.97	21,328.97

6/8/15

EDWARD BURCH 1911

TWIN CITY RAPID TRANSIT CO., MINNEAPOLIS.

The steam plant has the following equipment:

Twenty-eight 600-h. p., B. & W. boilers, with 150° of superheat, 175 pounds pressure, which on 1-inch draft, operate regularly at 1100-h. p. capacity; two 3500-kilowatt Allis-Corliss vertical engines; two 5000-kilowatt, and two 14,000-kilowatt Curtis steam turbo-alternators.

In the rebuilding of this plant, erected in 1902, two 16-foot by 220-foot tile and brick chimneys have been replaced by four 14-foot by 263-foot steel stacks, lined thruout with 4 inches of concrete; the Roney stokers which are suitable for eastern coals were replaced by chain grate stokers which burn either northern Illinois or Youghiogheny screenings to advantage; grate areas have been increased 20 per cent.; coal is now stored and flooded in concrete cells in place of being allowed to deteriorate in huge piles; cast iron fittings were replaced by steel fittings and nickel-bronze valve seats for the superheated steam; and the four vertical cross-compound, condensing Allis-Corliss engines are now being replaced by 14,000-kilowatt 5-stage and 6-stage vertical Curtis steam turbines. Storage of heat in water under full pressure is planned for peak loads.

Steam consumption of the steam engines is 22 pounds per kw.-hr.; of the small steam turbines, 20 pounds; of the 14,000-kilowatt, 14 pounds.

The peak load at the power plant is 35,000 or 50 kilowatts per car.

Two water power plants, with 16,000 kilowatts capacity, near the steam plant, carry the body of the railway load.

Power has been distributed since 1897 by means of underground 13,200-volt, paper-insulated cables, to 11 converter substations in Minneapolis and St. Paul, and on the interurban lines. The efficiency between the alternating-current bus and the car is 60 per cent.

Car equipment consists of eight hundred 45-foot, 22- to 25-ton, steel-framed motor cars, each equipped with from 200 to 300 h. p. in motors; and there are twenty-two 45-foot motor cars in ~~heavy freight~~ suburban service.

The 33-cycle, three-phase system was chosen in 1896, at which time seven 700-kilowatt alternators and five 600-kilowatt 660-volt railway rotary converters were purchased in connection with the equipment of the first water power plant. Plans were made to combine all electric railway and lighting power plants and interests, and the 33-cycle system was not only suitable for the railway rotary converters, but for the arc and incandescent lighting in the city of Minneapolis. Neither 25 nor 60 cycles would have been satisfactory for the combined service.

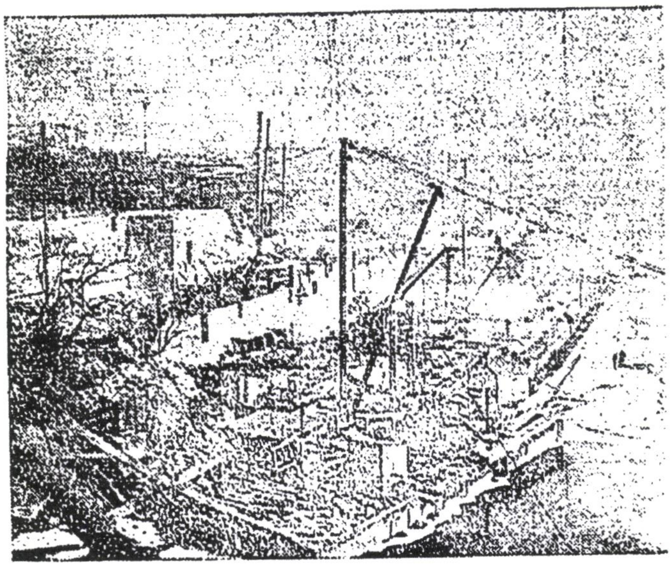
RUSHING THE WORK
Minneapolis Tribune (1867-1908); Mar 8, 1903;
ProQuest Historical Newspapers Minneapolis Tribune (1867-1922)
pg. A8

RUSHING THE WORK

ONE HUNDRE DAND FIFTY WORKMEN EMPLOYED ON RAPID TRANSIT COMPANY'S NEW POWER HOUSE.

There is an unusual and fortunate state of affairs—at least for the contractor—in the erection of the Twin City Rapid Transit Company's new $1,500,000 power house at Tenth avenue south and the river. The site of the structure is bed rock and the same stone that is being excavated to lay the foundation is being used to build the foundation itself.

When John Wunder, the contractor, undertook the work the ground was covered with grass and a heavy growth of stumpy bushes, without the slightest indication of the solid mass beneath. Before the plows had gone more than a few feet down, however, the stratum of rock was struck. At first this looked like an unforeseen expense, but as the contract specified that the foundation be of stone, Mr. Wunder decided to "quarry" the stone in sizes suitable for building instead of blasting it to bits.



Scene at construction of new Power House, foot of Tenth Avenue bridge southeast, John Wunder, contractor.

In this manner the cost of the foundation has been halved, for the expense of hauling away the waste stone and bringing the new, as well as the purchase price of the new stone, are all eliminated. Practically two-thirds of the material necessary for the foundation comes from the site. The remainder is being removed from the adjoining property.

The difference between ordinary blasting and "quarrying" is merely that in "quarrying" a vertical "face" or even surface is first given to the rock and light instead of heavy blasts are used at uniform distances with slight incisions made in the smooth side of the rock bed to give shape to the stone.

Not only the stone for the foundation, but the concrete, too, the most of which will be used in building the water sluice, is made right on the spot. A crusher, between whose iron jaws the waste rock is broken to small bits scarcely an inch through, is running from whistle blow to whistle blow. There is left but to mix the stones with the cement, a comparatively easy matter.

One of the difficulties in the construction of the building is the excavation for this same water sluice, the bottom of which is fifteen feet below the surface of the river. Several pumps are kept in constant operation, and even then there is always a few inches of water in the canal.

The water sluice is not intended to furnish water to run turbine wheels, as this is a steam not a water power plant, but will carry the liquid for use in the five immense condensing engines that drive the generators, which in their turn transmit through underground conduits the electric current that runs the street cars.

As a double safetyguard against flooding the workmen, a cofferdam has been built below the power house at a point where the bank of the river is lowest.

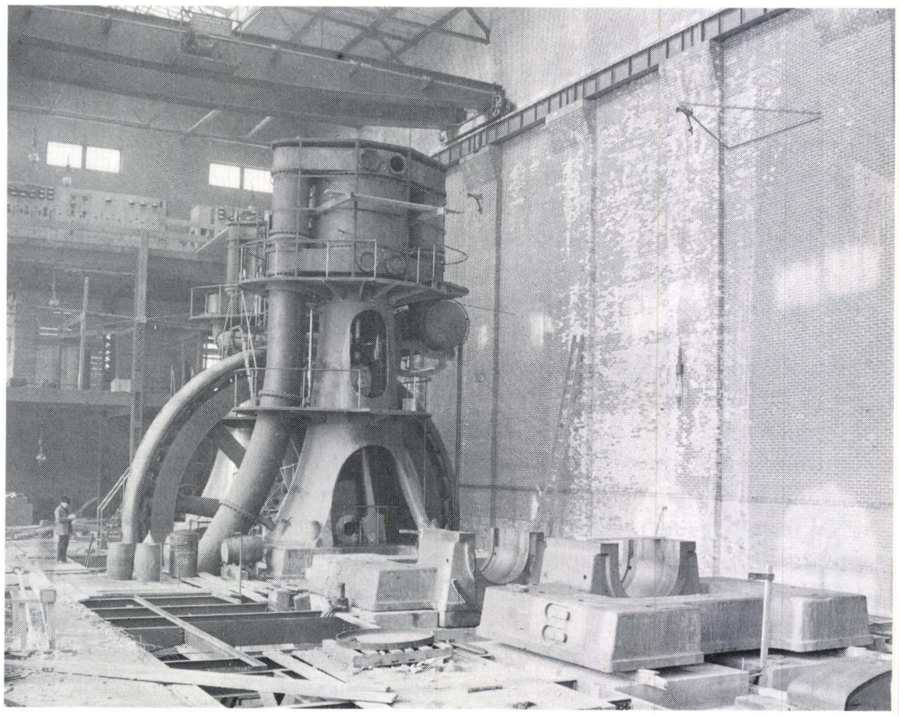
The blasting of the rock, which in this case is sandstone and unfit for use, to make way for the water sluice is not attended with the dangers it once was. The treacherous fuse has been dispensed with for some time. Now a man fifty yards away from the stick of explosive simply raises a lever which forms a circuit and discharges the blast with an electric current.

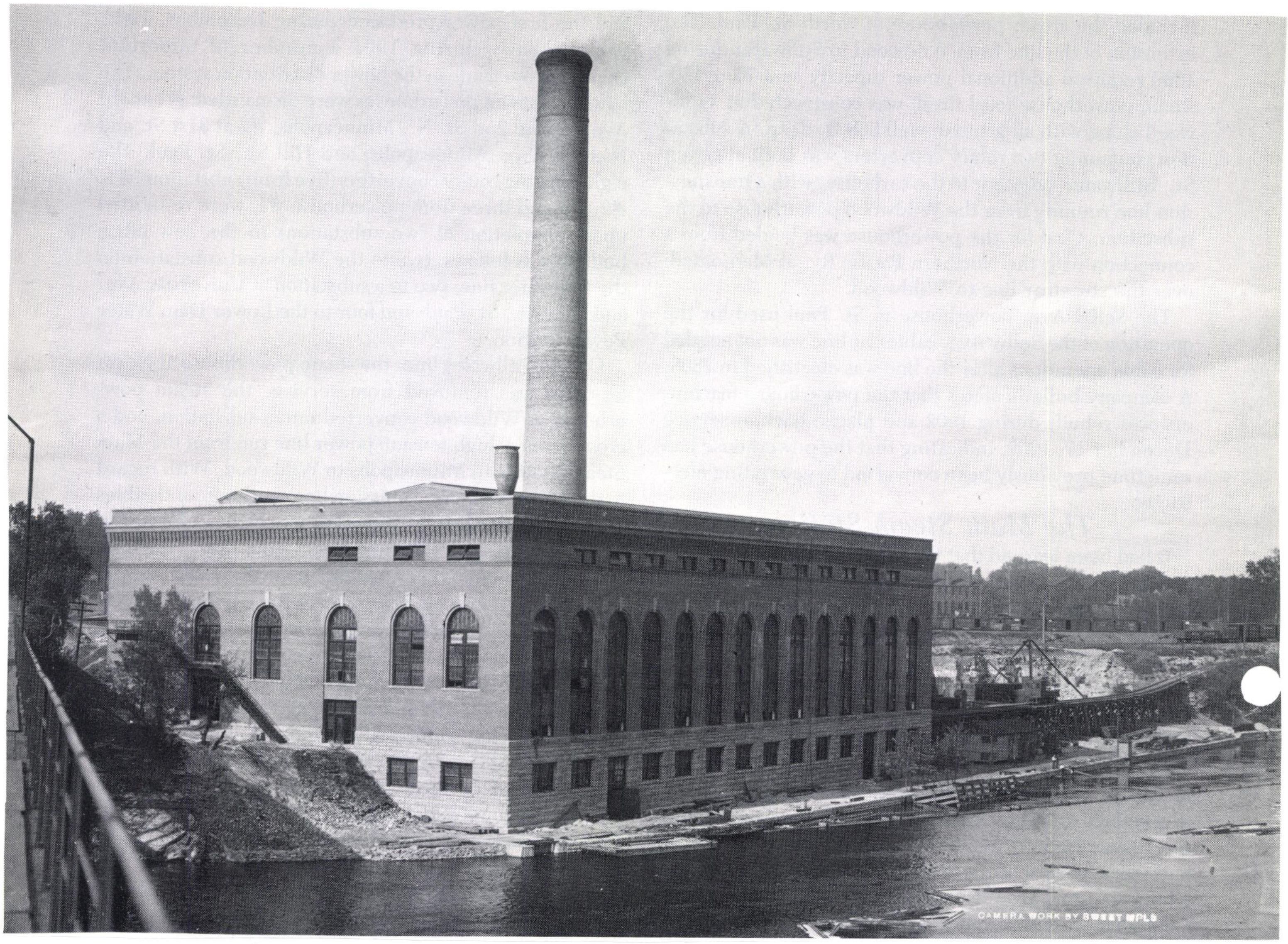
With the seven derricks and five engines, to say nothing of the 100 to 150 men employed, it is expected that this canal and the foundation as well will be completed within a few weeks. And while speaking of these derricks might be mentioned the almost human manner with which two of them work together.

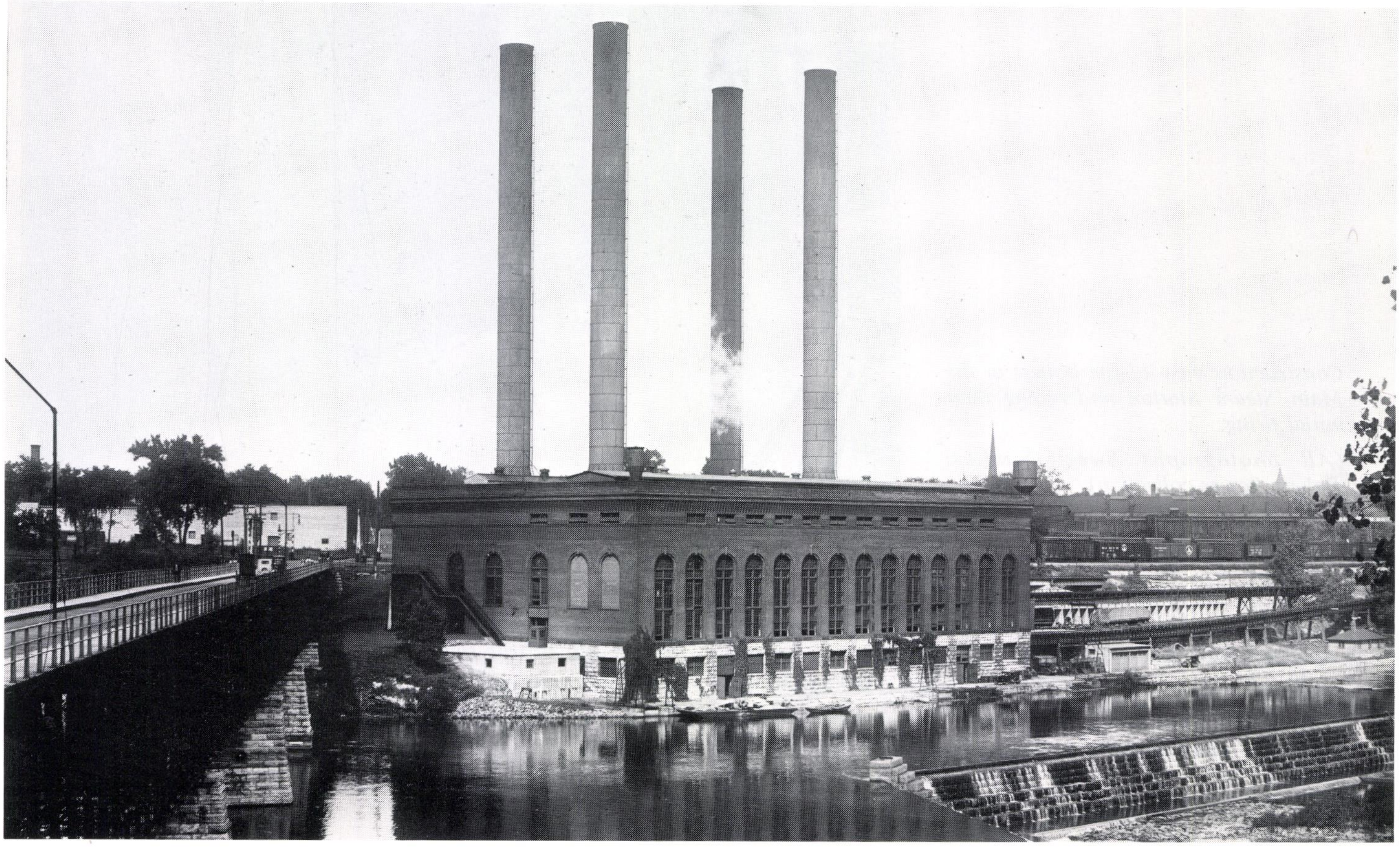
One medium sized machine reaches down into the water sluice ditch and carefully lifts two or three tons of rock over the high embankment. Before it gets time to lay the burden down again its larger companion stretches out his long arm and relieves the little worker of the load. Then, with short, sharp puffs and snorts the big fellow slowly raises the rock over a stone wall forty feet high and deposits it easily on the ground, when it is carried away by a miniature flat car over a miniature railroad track.

Of course there are men at the engines and at the point of transfer from one derrick to the other to hook and unhook the load, but they are so small in comparison with the machines that they seem to have no more to do with the operation than a flea on the back of one of the masons.

In connection with the building of this power house, he who has gone through the winter thus far with little coal and much cold may get some consolation and "learn a lesson" in forbearance in knowing that the workmen employed in the construction have missed but three days, and those in the middle of February when the thermometer registered 25 below zero. They have built the walls, drilled, blasted daily in the bitter cold and never a word of complaint from any of them, although their hands might be stiff from the cold and their bodies chilled to the bone.




CAMERA WORK BY SWEET MPLS

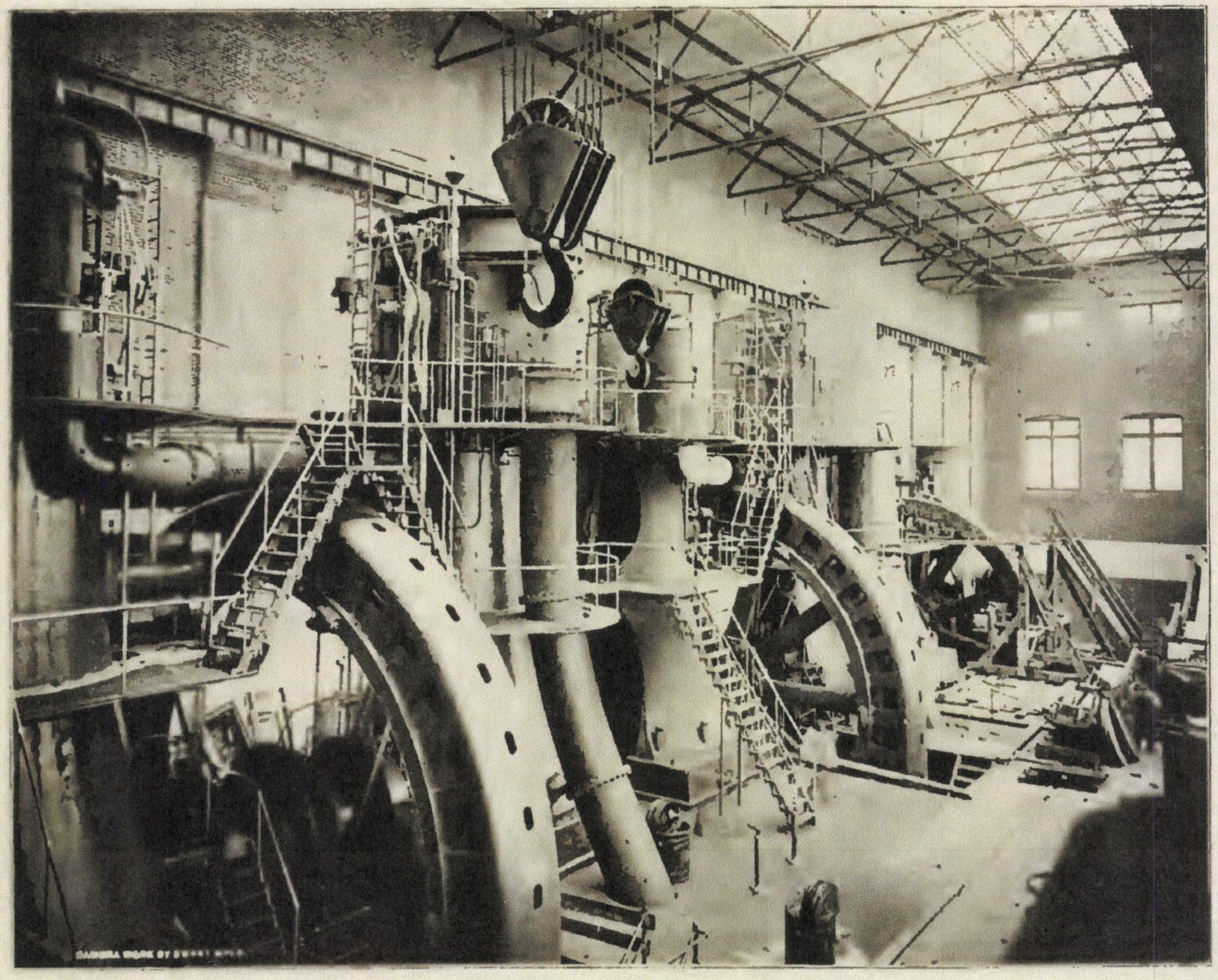


STREET RAILWAY REVIEW

Vol. XIV JULY 20, 1904 No. 7

New Power Installation of the Twin City Rapid Transit Co.

The extensive addition which the Twin City Rapid Transit Co., of Minneapolis and St. Paul, has found it necessary to make to its power equipment is an index of the success which has attended the operation of this company. The management of an urban transportation company always has difficulty in deciding where to draw the line between the conservatism that shall properly guard the interests of stockholders, and the optimism sure to be engendered by a study of street railways in America. Those to whom the success of the Twin City company is due have always taken a broad view of conditions, and the courage with which they have acted on their convictions has excited the admiration of all connected with the industry.



ENGINE AND GENERATOR ROOM, NEW POWER STATION, TWIN CITY RAPID TRANSIT CO.

The Twin City Rapid Transit Co. is one of the few of the larger systems in this country in which there has not been a change in management in recent years; Mr. Lowry, the president, and Mr. Goodrich, the vice-president, have been connected with the Twin City system for over 25 years, and Mr. Hield, the general manager, for 17 years.

Prior to 1898 the power for the Twin City Rapid Transit system was supplied from three steam stations, aggregating 10,500 h. p. in capacity, two located in Minneapolis and one in St. Paul. Jan. 1, 1898, the St. Anthony Falls Water Power Co. put in partial operation the water power plant built to supply current to the railway, and a few weeks later seven 700-kw. generators were in service. This water power plant, which was described in the "Review" for February, 1899, was designed for ten 700-kw. generators, and the intention was to abandon regular use of the two steam plants in Minneapolis. One of the steam plants was dismantled and the other held as a reserve.

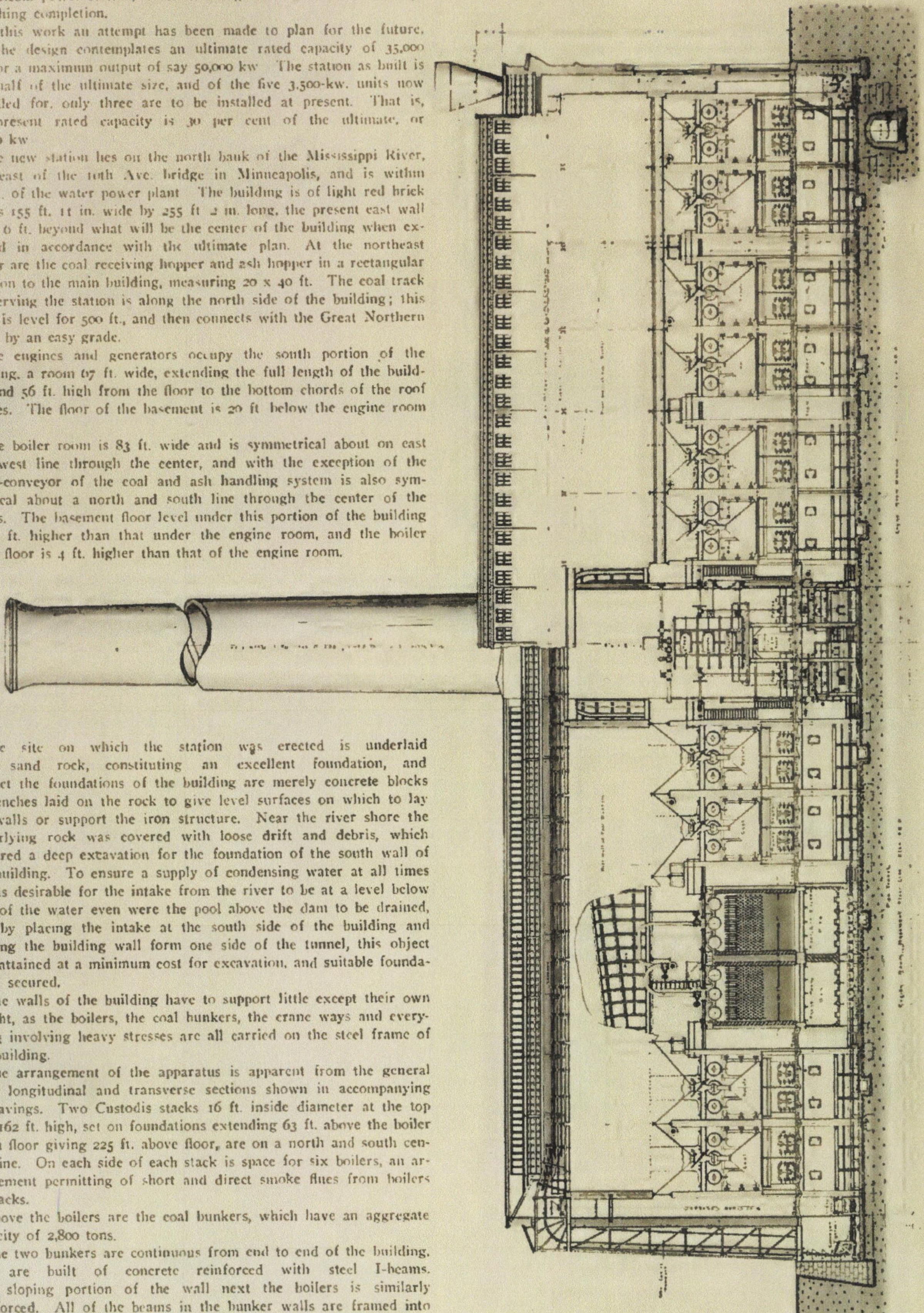
The rapid growth of the company's business, largely due to the numerous extensions and interurban lines which have been built during the past two years, led the company to plan the erection of a new steam power station, which was begun in 1902 and is now approaching completion.

In this work an attempt has been made to plan for the future, and the design contemplates an ultimate rated capacity of 35,000 kw., or a maximum output of say 50,000 kw. The station as built is just half of the ultimate size, and of the five 3,500-kw. units now provided for, only three are to be installed at present. That is, the present rated capacity is 30 per cent of the ultimate, or 10,500 kw.

The new station lies on the north bank of the Mississippi River, just east of the 10th Ave. bridge in Minneapolis, and is within 300 ft. of the water power plant. The building is of light red brick and is 155 ft. 11 in. wide by 255 ft. 2 in. long, the present east wall being 6 ft. beyond what will be the center of the building when extended in accordance with the ultimate plan. At the northeast corner are the coal receiving hopper and ash hopper in a rectangular addition to the main building, measuring 20 x 40 ft. The coal track for serving the station is along the north side of the building; this track is level for 500 ft., and then connects with the Great Northern R. R. by an easy grade.

The engines and generators occupy the south portion of the building, a room 67 ft. wide, extending the full length of the building and 56 ft. high from the floor to the bottom chords of the roof trusses. The floor of the basement is 20 ft. below the engine room floor.

The boiler room is 83 ft. wide and is symmetrical about on east and west line through the center, and with the exception of the cross-conveyor of the coal and ash handling system is also symmetrical about a north and south line through the center of the stacks. The basement floor level under this portion of the building is 10 ft. higher than that under the engine room, and the boiler room floor is 4 ft. higher than that of the engine room.



LONGITUDINAL SECTION THROUGH BOILER ROOM.

The site on which the station was erected is underlaid with sand rock, constituting an excellent foundation, and in fact the foundations of the building are merely concrete blocks or benches laid on the rock to give level surfaces on which to lay the walls or support the iron structure. Near the river shore the underlying rock was covered with loose drift and debris, which required a deep excavation for the foundation of the south wall of the building. To ensure a supply of condensing water at all times it was desirable for the intake from the river to be at a level below that of the water even were the pool above the dam to be drained, and by placing the intake at the south side of the building and making the building wall form one side of the tunnel, this object was attained at a minimum cost for excavation, and suitable foundations secured.

The walls of the building have to support little except their own weight, as the boilers, the coal bunkers, the crane ways and everything involving heavy stresses are all carried on the steel frame of the building.

The arrangement of the apparatus is apparent from the general plan, longitudinal and transverse sections shown in accompanying engravings. Two Custodis stacks 16 ft. inside diameter at the top and 162 ft. high, set on foundations extending 63 ft. above the boiler room floor giving 225 ft. above floor, are on a north and south center line. On each side of each stack is space for six boilers, an arrangement permitting of short and direct smoke flues from boilers to stacks.

Above the boilers are the coal bunkers, which have an aggregate capacity of 2,800 tons.

The two bunkers are continuous from end to end of the building, and are built of concrete reinforced with steel I-beams. The sloping portion of the wall next the boilers is similarly reinforced. All of the beams in the bunker walls are framed into the steel building structure, with girders placed to take the thrusts due to the coal pressure on each wall, and transmit them to the

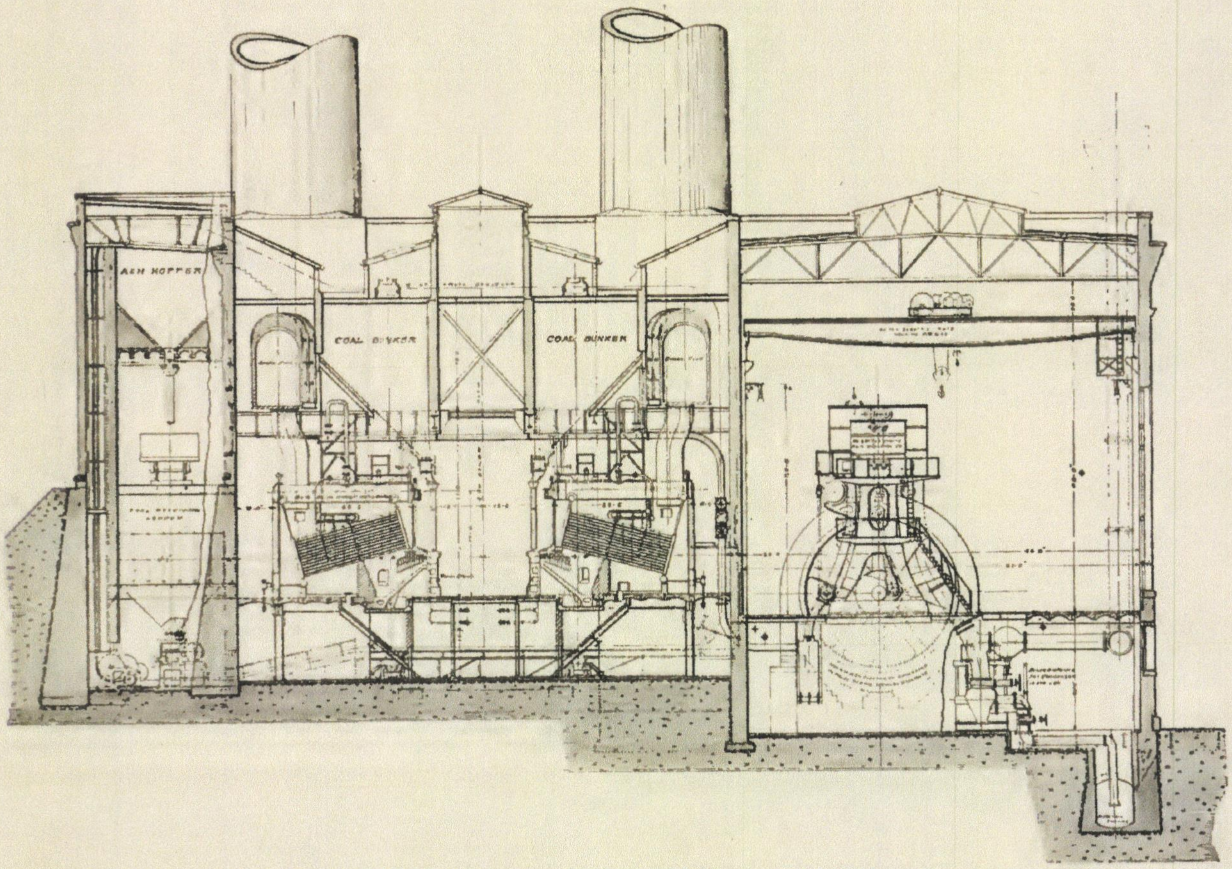
K&M Division
Torrance, Calif. 90503
POLY-VU

deep cross girders supporting the bunkers. This construction obviates the need of tie rods through the bunkers, which always give trouble because of their short life, and the obstruction offered to free flow of the coal. Over each boiler is a steel hopper, these hoppers forming, with the sloping wall, the bottom of the bunker.

By placing the coal bunkers back over the boilers as far as the flues permit, and dividing the capacity between two bunkers, space is gained for a wide light shaft. This shaft has a skylight in the roof and ample light is afforded. This arrangement was designed by Mr. Sargent to get ample light into the boiler room and is a radical change from the usual scheme of overhead bunkers, which shut off all light from the firing room.

The cross section also shows the location of the ash hopper, coal crushing machinery, and the conveyor lines.

Of the 24 boilers provided for in the portion of the building now built only 18 have been installed, these being sufficient for the present requirements of the company. All the boilers were built by the Babcock & Wilcox Co. and are of the all-steel construction, designed for 200 lb. working pressure. Superheaters designed to superheat the steam 120° F. above the temperature due its pressure at the point of leaving the boiler are installed within the boiler settings. Each boiler has three 36-in. drums, 23 ft. 3 in. long, set over 21 sections of 13 tubes, the tubes being 4 in. x 18 ft. The space occupied by each battery is 23 ft. 5 in. x 31 ft. and 20 ft. 4 in. high to the flange of the steam opening. The boilers have 5,500 sq. ft. of water heating surface, the nominal rating being 550 h. p., but they will furnish continuously 825 boiler horse power. All of the boilers are equipped with Roney automatic stokers, installed by Westinghouse, Church, Kerr & Co., and driven by Westinghouse engines, one engine being installed for each battery in accordance with the specifications of the consulting engineers. The active grate surface in each stoker is 110 ft., making the ratio of grate surface to heating surface 1 to 50 on water heating surface.



CROSS SECTION—NEW POWER STATION OF TWIN CITY RAPID TRANSIT CO.

The coal crushing and conveying plant was installed by the J. A. Mead Co. There are two longitudinal boiler room conveyors arranged to run over the coal bunkers above the boilers and under the ash pits beneath the boilers, and a cross-conveyor at the east end of the boiler room.

The coal is received in hoppers located to take the coal as dumped from cars on the railroad track, and from the receiving hoppers it is delivered to the crushers. From the crusher the coal is received by the cross conveyor, which passes over the lower lines of the two longitudinal conveyors, and into either of which it can deliver. The longitudinal conveyors elevate the coal and deliver it to the bunkers.

Ashes are taken from the pits under the boilers by the longitudinal conveyors and by them delivered to the upper line of the cross conveyor, which runs under the upper lines of the longitudinal systems, the cross conveyor carrying ashes to the hopper over the coal car track.

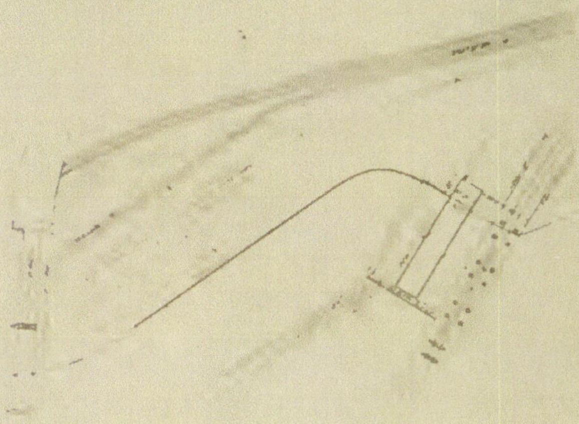
The conveyors are of the McCaslin continuous overlapping gravity bucket type, each line of conveyors running in a single plane. The lower horizontal runs under the ash pits are provided with continuous iron shields over the edges of the buckets and wheels, so that ashes may be received at any point without getting ashes or dust on the wheels.

The coal is crushed to pass a 1¼-in. screen, the crusher and entire conveying system having a capacity of 75 tons of lump coal per hour. The conveying plant is all driven by 500-volt motors.

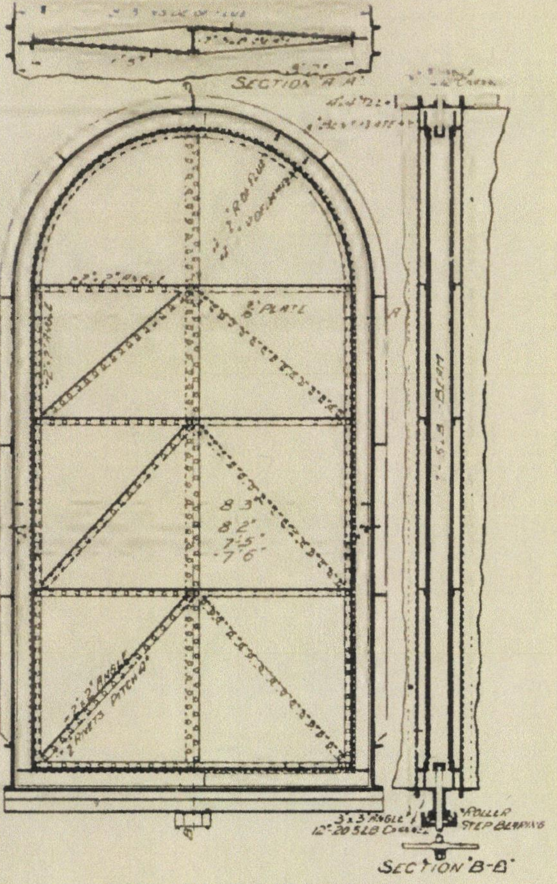
As is apparent from the general sections, the smoke flues extend either side of the stacks, each flue serving six boilers; these flues are of steel plate, reinforced with T shapes, and lined throughout with fire brick; at the stacks the flues are 8 ft. 3 in. wide by 15 ft. 9 in. high. For control of the draft a damper is placed in the uptake from each boiler. Each flue is also provided with a damper at the entrance to the stack, giving opportunity to isolate the flues and the corresponding boilers for repairs, or when not needed for power.

The damper is built of steel and is quite heavy, and to enable it to be handled easily the damper is mounted to turn about a vertical axis through its center of gravity and supported at the bottom in a roller step bearing. The damper, which is shown in detail in the drawing, has for its axis a 15-in. I-beam, to which are riveted sheets of 3-16-in. steel plate. Rigidity is given by 2-in. angles placed as indicated.

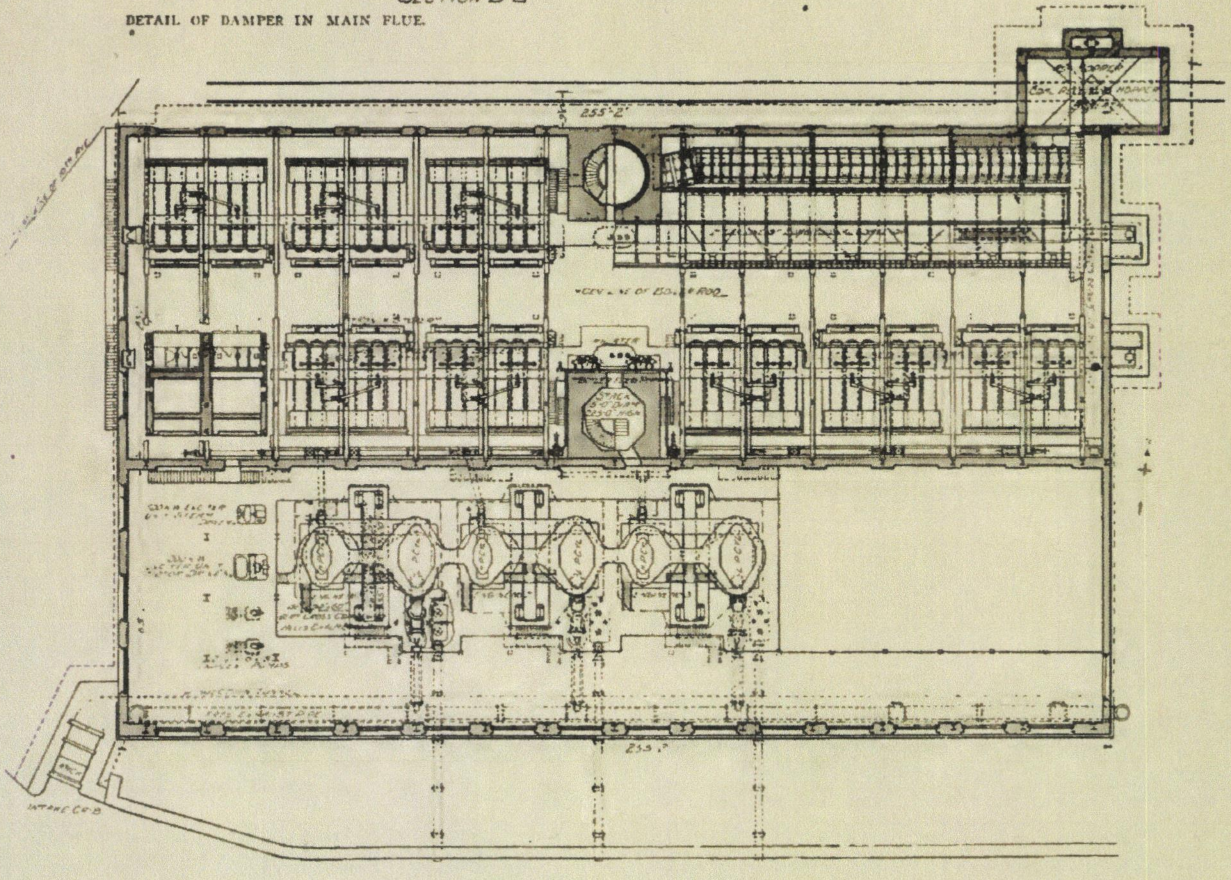
The scheme of high-pressure steam piping is shown in one of the accompanying engravings. The main header is of 16-in. wrought iron pipe with welded steel flanges and semi-steel fittings, and is carried on the wall behind the south boilers at 12 ft. 6 in. above the boiler room floor (16 ft. 6 in. above engine room floor). At the center of each battery of boilers a 12-in. steel pipe bent to 8 ft. radius is taken off, and on the other end of this is a short section of 12-in. pipe, into which are connected 7-in. leads from the two boilers of the south battery. These connections are curved to a radius of 3 ft. 3 in. Beyond this point a 10-in. pipe is carried across the boiler room and into this connect the two 7-in. leads from the north battery of boilers.



PLAN OF STATION SITE.



DETAIL OF DAMPER IN MAIN FLUE.



GENERAL PLAN OF MAIN STATION.

The south stack divides the main header into two sections, which are connected by a 14-in. pipe carried through the engine-room basement.

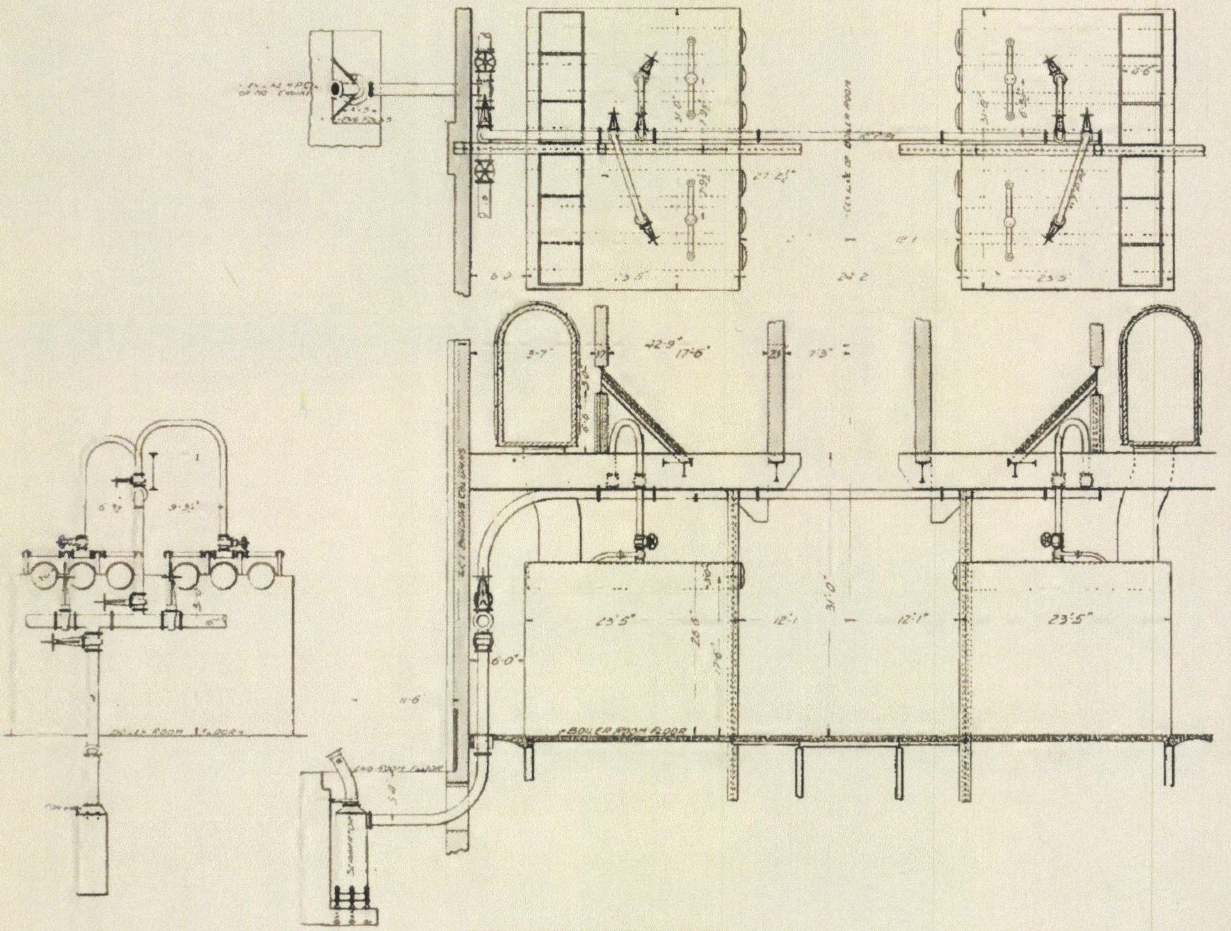
The leads to the engines are 14 in. in diameter and (excepting the one for the engine opposite the stack) are carried down to the boiler-room basement, and thence through the wall (with a bend of 6 ft. radius) to connect with 16-in. "Straight Line" separators, made by the Direct Separator Co., of Syracuse, N. Y., into which the high-pressure piping drains. In each case the separator is set at the edge of the engine foundation, and supported on helical springs to take up expansion of piping and vibration. From the top of the separator a 14-in. pipe leads to the high-pressure cylinder, following the general contour of the engine frame. The steam being superheated, there is no water discharged from the separator except when starting the engine; Bundy traps are provided to drain the separators.

The valves throughout are of the Crane make, all high-pressure valves in pipes above 8 in. in diameter having by-pass.

For the steam-driven exciter unit a 4-in. lead is taken from the main header. In this is a 4-in. "Straight Line" separator.

There are now installed three main generator units, each consisting of an Allis-Corliss vertical cross-compound condensing engine direct connected to a G. E. 3,500-kw. three-phase flywheel type alternator. Current is generated at 34 2-3 cycles, this periodicity being chosen to permit the operation of the plant in multiple with the company's water power plant. It will be remembered that the water power plant was designed in 1897, and at that time 25 cycles had not become so widely accepted as standard for railway work. There was, consequently, at that time no reason for not adopting 34 2-3, for which the hydraulic apparatus was more readily adapted. The engines are designed for a maximum capacity of 9,000 h. p. each.

The diameter of the revolving field which acts as the flywheel is about 26 ft. and this flywheel has the equivalent mass of 308,000 lb., acting at the radius of gyration of 12.2 ft. The angular variation under normal conditions is guaranteed not to exceed .09°. The variation of speed under sudden change of load is within the limits of 73 and 76 r. p. m. The flywheel is of the laminated type, the rim consisting of segments of ⅛-in. steel plate about 3 ft. long. These are assembled in sets of four, so that the cross section of the rim shows at least three solid plates out of every four. Cover plates are placed on the outside of the thin segments, the whole being held together by 1⅛-in. bolts, with the ends riveted. The laminated segments are dovetailed on both concave and convex edges; the dovetails on the inner edge engage over corresponding projections on the spoke castings, while those in the outer edge serve to hold the field pole pieces. This construction insures safety in operation, and the design is economical inasmuch as it is cheaper to punch the plates than to machine a casting.

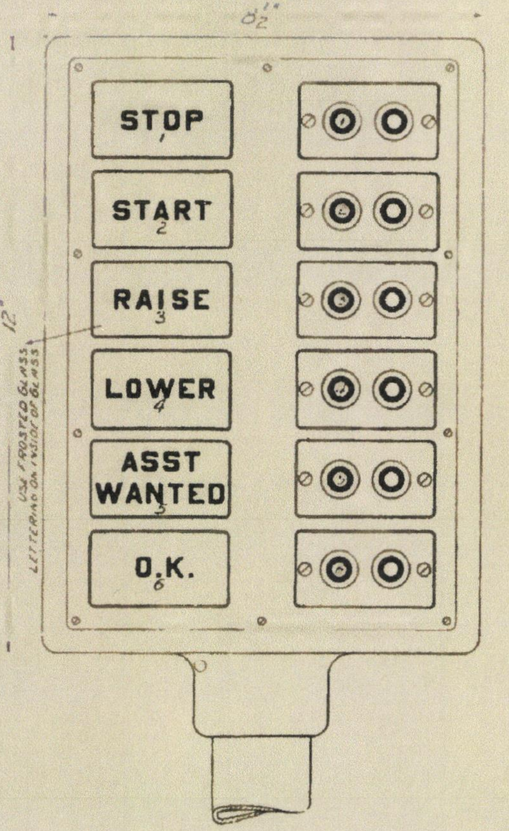


HIGH PRESSURE STEAM PIPING.

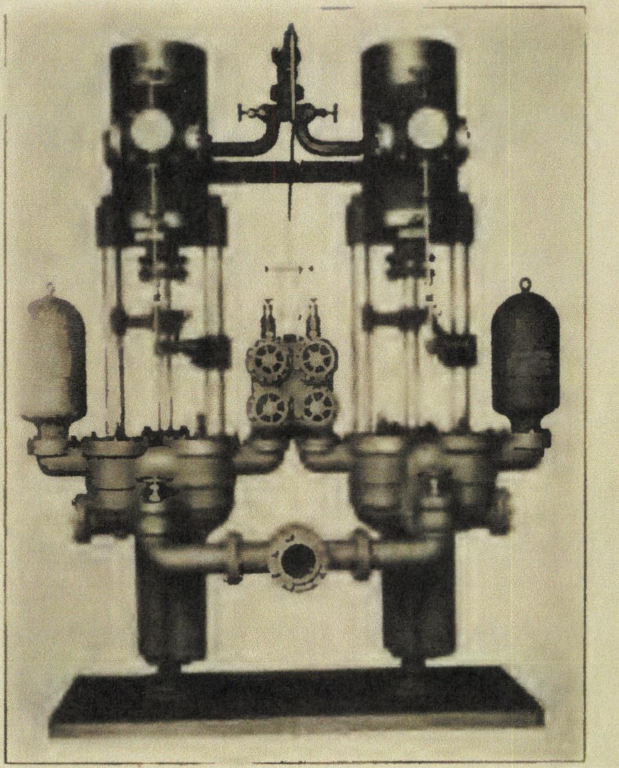
The shaft is hollow forged, oil tempered steel, made by the Bethlehem Iron Works, and has main journals 30 x 60 in. The lower shells for the journal boxes are spherical and are fitted accurately to corresponding recesses in the bed plate, giving the ball and socket bearing. All of the engines have automatic stop and butterfly valves, controlled by separate governors.

The cylinders are 46 and 94 in. in diameter, respectively, and the stroke 60 in. The valves are placed in the cylinder heads, the steam and exhaust valves being driven from separate eccentrics. A horizontal receiver without heating coils is placed between the two cylinders. The cylinder, reservoir and piping are all covered with Johns-Manville asbestos fireproof felt, over which is placed planished iron.

The station is equipped with double pressure-oiling systems. All the crank pit pockets, bearings, pump drip pans, etc., drain to two size A Turner oil filters, which are mounted in the basement above


8½"
12"
USE FROSTED GLASS
LETTERING ON INSIDE OF GLASS
STOP
1
START
2
RAISE
3
LOWER
4
ASST
WANTED
5
O.K.
6

SIGNAL BOARD.



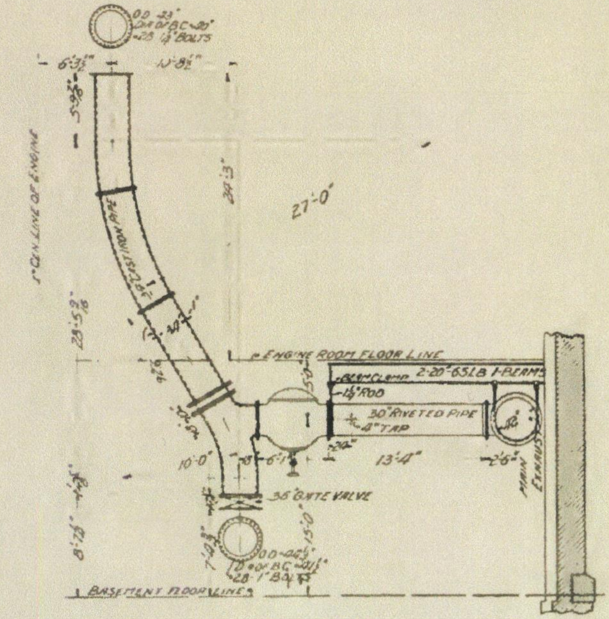
DEAN BROS. "ATLANTIC" TYPE FEED PUMP.

the main oil reservoir. From the tank oil is pumped to reservoirs in the boiler room, from which distribution is made under gravity head.

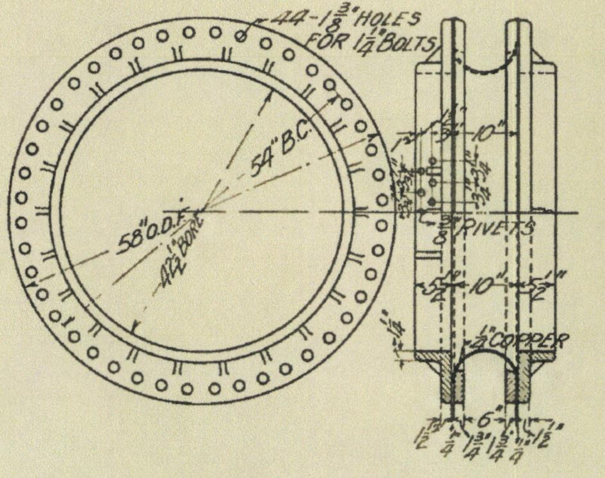
Cylinder oil is also distributed to the cylinder oil pumps at the engines, from a reservoir mounted at a suitable height in the boiler room.

The exhaust piping between the main engines and condensers is of cast iron, 34 in. in diameter, the connection with the condenser being a 36-in. special narrow gate valve. The atmospheric exhaust main is 42 in. in diameter, of riveted pipe, with cast iron flanges. Each engine exhaust connects with the atmospheric exhaust through a relief valve and a section of 30-in. riveted pipe.

In the exhaust piping, both cast iron and riveted sections, expansion joints of a somewhat novel type are inserted. The details of the expansion joints for the atmospheric exhaust main are shown in one of the drawings. In this the flexible portion is a ring of ¼-in. copper plate rolled to give a U-shape in cross-section. The internal diameter of the bend is 9½ in. and the straight flanges are 3 in. long. The copper section is held against the pipe flanges by cast iron rings bolted to the flanges. The joints for cast pipe do not differ in dimensions except for the diameter.

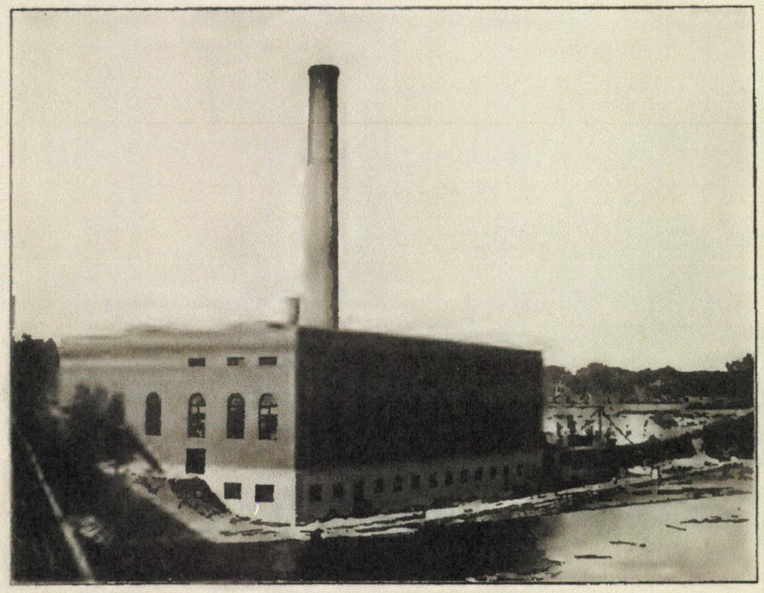

OD 23"
DIA OF BC 20"
28 ¼" BOLTS
6'3½"
10'8½"
5'9⅝"
CEN. LINE OF ENGINE
34'3"
27'-0"
CAST IRON PIPE
23'5⅜"
ENGINE ROOM FLOOR LINE
BEAM CLAMP
2-20"-65LB I-BEAMS
1½" ROD
30" RIVETED PIPE
4" TAP
10'-0"
6'1"
13'4"
2'6"
36" GATE VALVE
MAIN EXHAUST
15'-0"
8'7⅝"
OD 46½"
DIA OF BC 41½"
28-1" BOLTS
BASEMENT FLOOR LINE

EXHAUST PIPING.


44-1⅜" HOLES
FOR 1¼" BOLTS
54" B.C.
58" O.D.F.
42½" BORE
10"
⅝" RIVETS
5½"
10"
5½"
¼" COPPER
6"
1½"
¼"
1¾"
1¾"
¼"
1½"

DETAIL OF EXPANSION JOINT IN EXHAUST PIPE.

Each engine has a separate steam-driven jet condenser These condensers are of the vertical twin air pump type, made by the George F. Blake Manufacturing Co., of East Cambridge, Mass. The water cylinders are each 48 in. in diameter by 24 in. stroke,



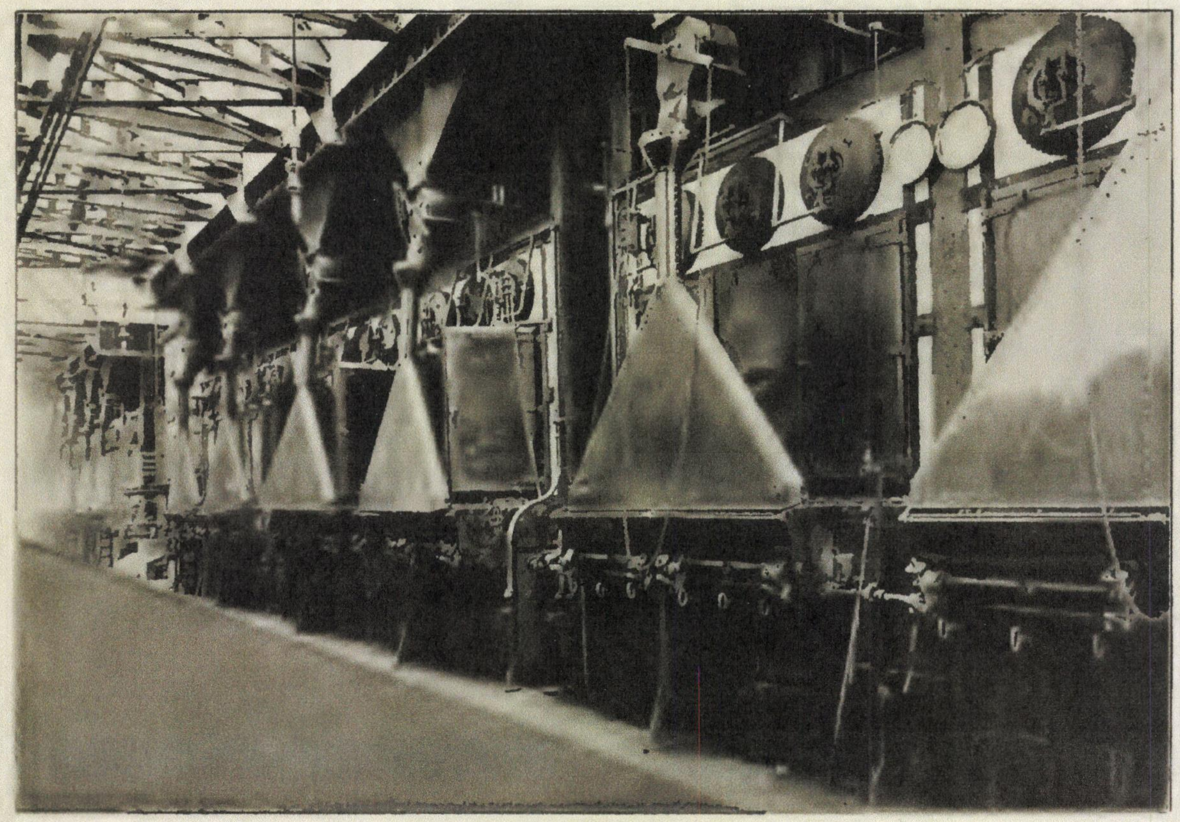
EXTERIOR OF POWER STATION.

and the steam cylinders 18 in. in diameter by 24 in. stroke. The piping is arranged so that the pumps may exhaust into the engine receivers when so desired. The injection pipes connecting the condensers with the intake are made very short and direct, by reason of the location of the condensers with respect to the tunnel, and the opportunity for leaks correspondingly reduced.

The feed-water piping system is such that either hot or cold water can be supplied to the boilers, the arrangement being as follows: The 14-in. suction pipe from the intake tunnel supplies the service pump. From the service pump is an 10-in. discharge to the feed-water heater. From the heater a 10-in. pipe leads to the basement and extends under the two pairs of twin feed pumps. From the 10-in. hot water main a 6-in. riser goes to each pair of pumps. A second 8-in. main is carried from the service pump to the feed pumps, and thence continues to the heater, forming a loop with the regular heater supply and providing two paths to the heater. This second 8-in. main has numerous outlets for service purposes, in the basement and into the boiler room, and branches are run to each condenser to supply forced injection for priming.

Each feed pump has two discharge passages, one for use when supplying the cold water and the other for use when supplying the hot water boiler-feed mains. These feed mains are each 5 in. in diameter and are carried along the basement suspended in the same vertical plane just below the main floor beams, and run in front of the boilers. One pair of pumps has capacity to feed all the boilers; each pair is connected to the feed mains for one side of the boiler room, but in the center the two feed lines are tied together with cross connections, so that any of the pumps may supply water for any of the boilers. From the feed mains 2½-in. branches are taken for the boilers, one branch rising each side of each battery. From the cold water feed main are also taken 1½-in. branches for supplying water to operate boiler-tube cleaners, and to wash the boilers. As one pair of feed pumps can supply the hot feed to the boilers, cold water under pressure may always be available for auxiliary purposes.

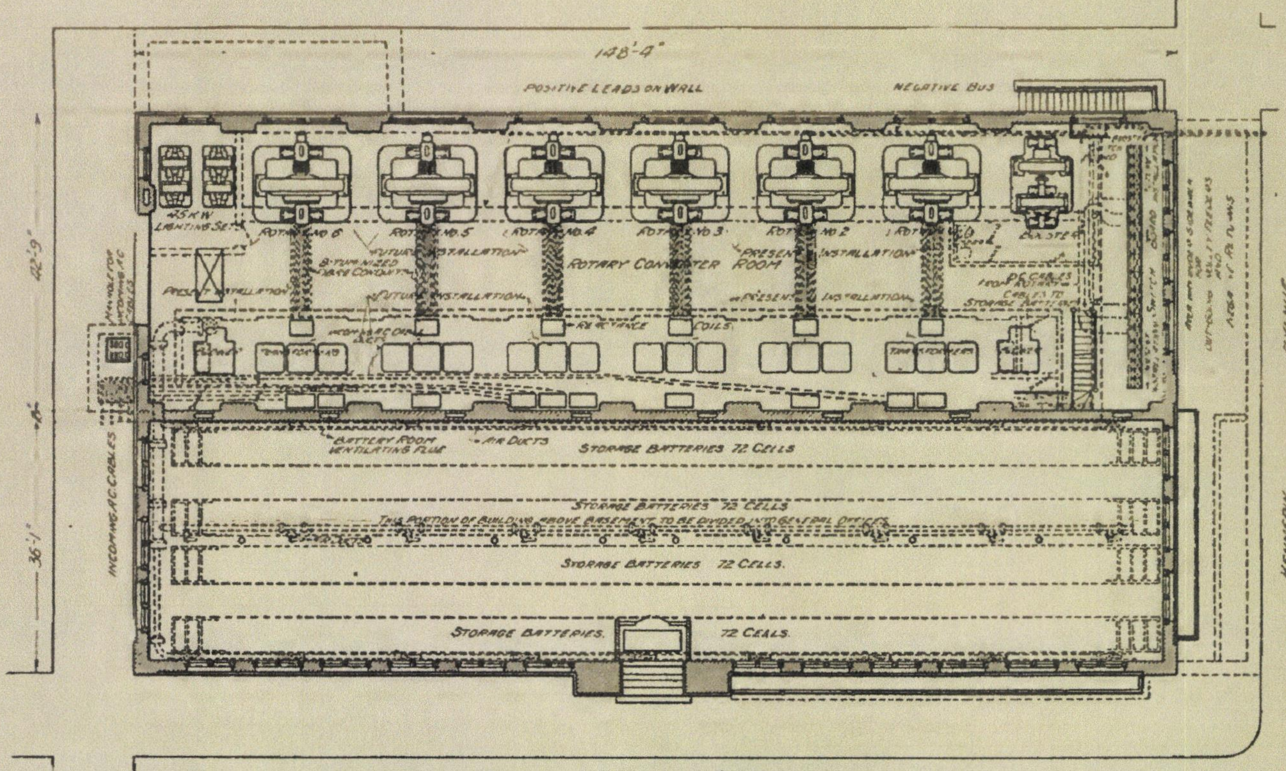
The feed pumps are the "Atlantic" type of twin, vertical, double-acting boiler feeders, made by Dean Bros., of Indianapolis, with steam cylinders 14 x 24 in. and water cylinders 10 x 24 in. Each pump, when operating with steam at 140 lb. pressure and at a speed of 40 strokes per minute, has a capacity of 325 gallons per minute against 180 lb. boiler pressure. The pumps are fitted with brass removable liners; the valves are in nests and are conveniently removable with the seats when necessary. The service pumps, two



BOILER ROOM OF NEW POWER STATION—TWIN CITY RAPID TRANSIT CO.

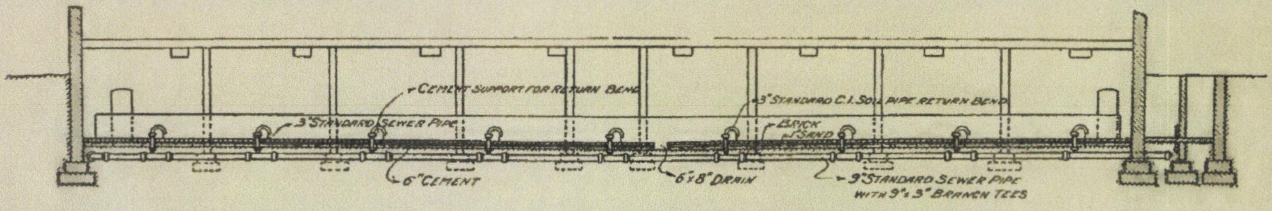
in number, are of the Dean Bros. horizontal duplex type, 12 and 16 x 18 in. in size, and when supplied with steam at 110 lb. pressure, operating at 45 strokes per minute, will deliver 1,400 gallons of water per minute against a pressure of 40 lb. per sq. in.

The feed-water heater is of the open type, made by the Stilwell-Bierce & Smith-Vaile Co., and is 11 ft. 6 in. x 6 ft. 7 in. x 16 ft. 4 in. high and is set on a platform 10 ft. 3 in. above the boiler room floor. A 14-in. steam inlet and 8-in. outlet are provided. The exhaust from all the auxiliary apparatus in the station is led normally to the heater which has a capacity for heating 350,000 lb. of water per hour from 60 to 210 degrees F.


148'-4"
POSITIVE LEADS ON WALL
NEGATIVE BUS
25 K.W. LIGHTING SET
ROTARY NO. 6
ROTARY NO. 5
ROTARY NO. 4
ROTARY NO. 3
ROTARY NO. 2
ROTARY
EXCITER
FUTURE INSTALLATION
BITUMINIZED FIBRE CONDUIT
PRESENT INSTALLATION
ROTARY CONVERTER ROOM
REACTANCE COILS
TRANSFORMER
TRANSFORMER
DC CABLES FROM ROTARY
CABLES TO STORAGE BATTERIES
SWITCH BOARD
MANHOLE FOR INCOMING A.C. CABLES
INCOMING A.C. CABLES
22'-9"
36'-1"
BATTERY ROOM VENTILATING FLUE
AIR DUCTS
STORAGE BATTERIES 72 CELLS
STORAGE BATTERIES 72 CELLS
THIS PORTION OF BUILDING ABOVE BASEMENT TO BE DIVIDED INTO GENERAL OFFICES
STORAGE BATTERIES 72 CELLS
STORAGE BATTERIES. 72 CELLS.
HENNEPIN AVENUE
ELEVENTH STREET

GENERAL PLAN OF SUB-STATION IN MINNEAPOLIS.

For transmitting orders between the engines and switchboard signal boxes are placed one at the throttle of each engine, and one on the switchboard gallery, thus making a pair of boxes for each generating unit. The signal box, shown in front elevation in the engraving, is 12 in. high, 8½ in. wide and 5 in. deep, made of brass, and supported on a pipe standard which serves as a conduit for the connecting cables. The box is divided into two equal compartments, one containing the lamps and the other the push switches controlling them. The six signs are painted on the back of frosted glass, and behind each is a pair of candelabra 125-volt lamps mounted in miniature receptacles; the receptacles are mounted on a fiber base, the two lamps of each pair being in multiple so that one burned-out lamp will not prevent the indication.


CEMENT SUPPORT FOR RETURN BEND
3" STANDARD C.I. SOIL PIPE RETURN BEND
3" STANDARD SEWER PIPE
BRICK
SAND
6" CEMENT
6"&8" DRAIN
9" STANDARD SEWER PIPE WITH 9"x3" BRANCH TEES

CROSS-SECTION THROUGH BATTERY ROOM IN SUB-STATION.

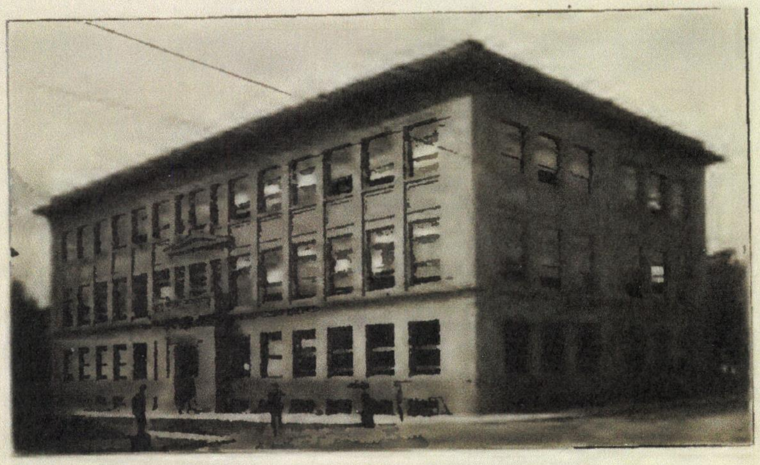
The station is provided with a complete system of compressed air piping designed for an operating pressure of 40 lb. per sq. in., but tight for 80 lb. pressure. The tank for this is 24 in. x 6 ft. Two air outlets are placed at each generator, one at each exciter unit and three on each switchboard gallery.

The station is served by a 40-ton electric traveling hoist, furnished by the Whiting Foundry & Equipment Co., and the work of installing machinery was further facilitated by laying a railroad track into the building, enabling loaded cars to be run under the crane.

The water power station is to be operated whenever water is available, but the distribution will be made from the new station. With this in view, the new electrical power equipment includes three banks of transformers, each consisting of three 550-kw. transformers to raise the voltage of the water-driven generators from 3,450 to 13,200 volts, the potential at which the main units in the new station deliver current. These transformers, along with two 45-in. Buffalo fan blowers driven by 10-h. p. 500-volt direct-current motors, are located in the water power station; 500-volt motors for blowers were adopted in this station because current at this voltage is always available, while in order to obtain lower voltage alternating-current, step-down transformers would have to be installed.

The leads from the water power station to the main station are triple-conductor, paper-insulated, lead-covered cables, three in number, one going to each of the three sections into which the main station high-tension bus bars are divided.

The control switchboard for the main station is of blue Vermont marble and is located at the west end of the engine and generator room, where there are two galleries. On the upper gallery provision is made for 10 alternating-current generator panels (3 now installed), 2 panels to control the a. c. side of motor-driven exciter sets (1 now installed), 3 panels to control incoming lines from the water power plant, 1 bus sectional panel, 9 outgoing line panels (6 now installed), and 3 panels to control direct-current side of exciter sets.

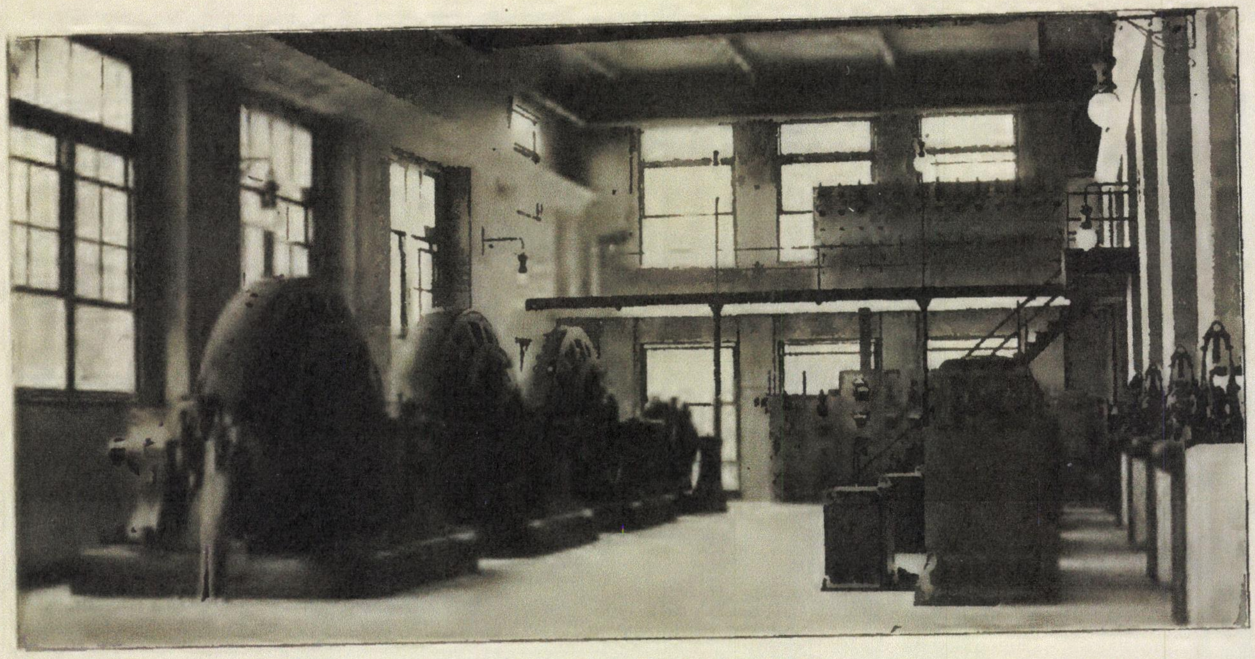


EXTERIOR VIEW MINNEAPOLIS SUB-STATION.

On the lower gallery are the offices, and when the station is completed there will be installed here the bus bars, oil switches and switchboard panels for 12 additional feeder lines, making a total of 21 outgoing feeders, for which provision has been made.

The bus bars are of copper, ¼ x 2 in., and are mounted in compartments 23½ x 12⅜ in.

The bus bars are divided into three sections. Between adjacent sections are oil switches, with disconnecting knife switches on each side, so that the oil switches can be isolated when desired. Disconnecting switches are also placed between the bus bars and oil switches on the generator leads, and between the bus bars and oil switches on the feeder lines. Also in each branch of each feeder circuit, between the oil switch and the triple conductor cable, is a disconnecting switch; each of the static dischargers for the feeders is similarly provided with a disconnecting switch so that it can be isolated for repairs when necessary.



INTERIOR OF MINNEAPOLIS SUB-STATION.

The oil switches for the generator circuits extend in a line across the building; behind and parallel to these is the bus-bar structure; behind this and parallel to it is the second row of oil switches for the feeder lines. All the oil switches are furnished with specially designed Kinnear rolling doors. This apparatus is located on the gallery behind the switchboard.

Connections between generators and the oil switches are made by 250,000-c. m., three-conductor, paper-insulated, lead-covered cables, which are run in 4-in. pipe suspended from the basement ceiling. The cables were furnished by the General Electric Co. At the generator leads are carried through 6-in. wrought iron pipes embedded in the engine foundation, these pipes being bent to bring the leads cable from the floor level to the lower side of the armature in an easy curve. The field leads at the generators are similarly protected by 2-in. wrought iron pipe.

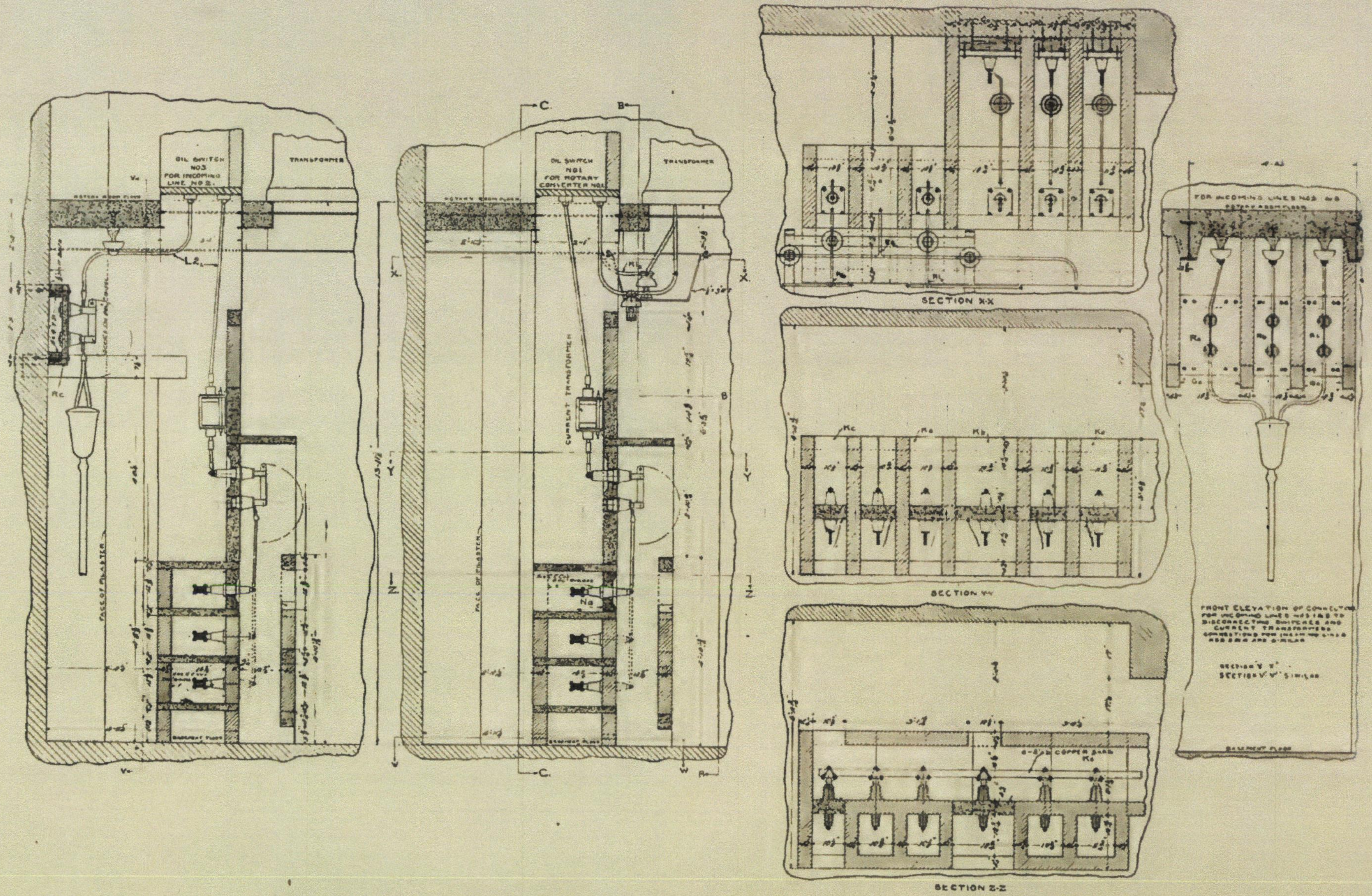
The exciter units are under the switchboard gallery. There are now installed one steam-driven set consisting of a 50-kw., 125-volt generator and a 11 x 11-in. simple engine operating at 280 r. p. m., and one motor-driven set, consisting of a 200-kw., 125-volt generator and a 440-volt three-phase induction motor operating at 520 r. p. m.

The positive bus bar for the field circuits is placed under the engine-room floor.

There are no transformers in the main steam station, excepting for the exciter motors, the generators delivering current at 13,200 volts, which is also the potential for the distribution system. Of the six feeder lines now installed, two go to the sub-station in Minneapolis, two to the sub-station in St. Paul, and two supply the Stillwater line, going to what is known as the Wildwood station.

Outgoing current is carried by triple conductor cables laid in tunnels or in conduits wherever the lines are within the city limits; outside of the city limits to Wildwood they are carried on poles. These cables were furnished by the National Conduit & Cable Co.

The two new sub-stations, which have been built, one at Hennepin Ave. and 11th St. in Minneapolis, and the other at Wabasha and College Aves. in St. Paul, are almost exactly similar in design and are for an ultimate rated capacity of 9,000 kw. each in rotary converters. The buildings are according to architectural plans of Mr Charles F. Ferrin, of the Twin City company, the electrical work,


OIL SWITCH NO 3 FOR INCOMING LINE NO 2
TRANSFORMER
ROTARY ROOM FLOOR
L2
OIL SWITCH NO 1 FOR ROTARY CONVERTER NO 1
TRANSFORMER
CURRENT TRANSFORMER
FACE OF PLASTER
BASEMENT FLOOR
C
B
X
Y
Z
SECTION X-X
SECTION Y-Y
SECTION Z-Z
FOR INCOMING LINES NOS 1 & 2
FRONT ELEVATION OF CONNECTIONS FOR INCOMING LINES NOS 1 & 2 TO DISCONNECTING SWITCHES AND CURRENT TRANSFORMERS
SECTION V-V SIMILAR

SECTIONAL ELEVATIONS AND PLANS THROUGH OIL SWITCHES AND BUS BAR COMPARTMENTS—ST. PAUL SUB-STATION.

floor framing, bus-bar and battery room being designed by Sargent & Lundy. The lower part of the structure is stone, and above this the walls are of light buff speckled pressed brick; the roof is of concrete. Inside the walls are of pressed brick, with a wainscoting of white enamel brick. The rotary converter room is floored with white tile.

The ground dimensions of the sub-station are 148 ft. long by 80 ft. wide. At one side is the rotary converter room, 41 ft. wide inside; below this is a basement, with part partitioned off for an air-pressure and high-tension chamber. The other section of the building, 33 ft. wide, excepting the basement, which is the battery room, is occupied by offices, which are arranged on three floors. The third office floor also extends over the rotary converter room. The offices at both sub-stations include rooms for the use of Mr. Lowry, Mr. Goodrich and Mr. Hield, as well as for the local operating staff and heads of departments.

The general arrangement of the apparatus in the sub-stations is apparent from the drawing, but there are several features to which especial attention should be directed.

The storage battery room is thoroughly ventilated by means of a system of underground ducts which is of admirable as well as novel design. The battery room is 34 ft. wide by 145 ft. long and contains 288 cells with type H plates, made by the Electric Storage Battery Co., of Philadelphia. The capacity of the battery is 1,000 kw. for one hour, and the tanks are of a size to permit addition of plates to give 1,500 kw. total capacity. The tanks are arranged in four rows. The floor is laid with vitrified bricks, and underneath are three lines of 9-in. standard sewer pipe, one in the center of the room and one at each side wall. These extend the entire length of the building and at intervals of 17 ft., 3-in. branches are brought up through the floor, terminating in 3-in. standard cast iron soil pipe return bends. The bends are supported on concrete blocks so that the opening into the room is directed downwards and is 4 in. above the floor.

The 9-in. longitudinal mains are connected by a 15-in. cross-main carried to the fan room. Ventilation is secured by admitting air from the pressure chamber through the pipes into the battery room. Flues for exit of air are placed at the ceiling.

The sub-stations are each designed for six 1,500-kw. rotary converters; but one-half of this number is now installed. These are General Electric machines, with 16 poles, and operate at 260 r. p. m.; they are designed to operate in multiple on both a. c. and d. c. sides, taking 34 2-3 cycle, three-phase current at 430 volts and delivering direct current at 600 volts.

As the machines will carry a 50 per cent overload for two hours, the maximum output with the present equipment is 6,750 kw. for two hours, or with the battery 7,750 kw. for one hour.

The rotaries are arranged along the outer wall of the station. At one end of the building is the booster for regulating the battery. This is a differential wound machine, built by the Western Electric Co., Chicago. At the opposite end of the room are two G. E. motor-generator units—75-h. p. 600-volt motor and 45-kw. 110-volt generator—which are for lighting the sub-station and offices; one machine will carry this load, and normally only one is operated.

Each sub-station has nine 550-kw. single-phase air-blast step-down transformers for reducing the incoming current from 12,500 volts to 430 volts for the rotaries. The transformers are ranged opposite the rotaries, with reactance coils in front of each group and the corresponding oil switches between the transformers and the wall.

The bus-bar structure is located in the air-pressure chamber under the transformers. The bus bars are divided into two sections by air-brake switches, each section (when the complete equipment is installed) having two feeder lines and three rotaries.

The two sub-stations, as already stated, are of similar capacity, and the principal differences between them lie in the relative arrangement of the transformers, oil switches and high-tension bus bars. The sub-station plan we show is that for the Minneapolis station; the drawings showing the bus-bar construction are for the St. Paul sub-station, as this is considered the better design of the two. The relative arrangement of the high-tension apparatus in the two stations will be apparent from these drawings.

All lines enter and leave the station underground. The path of the incoming current is first through oil switches to the bus-bars in the basement, thence from the busbar through oil switches to the transformers. From the low-tension side of the transformers the cables to the rotary converters are carried through electrolysis-proof conduits in the floor.

The positive and negative direct-current buses are separated as far as possible, one being on each wall. The positive terminal blocks for the rotaries are not placed on the machines, but have been mounted on the wall with the positive leads, an arrangement which is an additional protection against a breakdown between the positive lead and the frame of the machine.

All of the converters will have alternating-current starting switches mounted on top of the reactance coils, and, while the rotaries may be started from either side, they will in normal operation be started by alternating current only.

The sub-station switchboard for incoming lines, rotary converters and booster is on the main floor. The board for the direct-current feeders is in a gallery, the feeders being hidden from view in the wall, which is of channel iron construction.

The cooling for sub-station transformers is effected by two 70-in. Buffalo fans driven at 525 r. p. m. by 75-h. p. 350-volt induction motors.

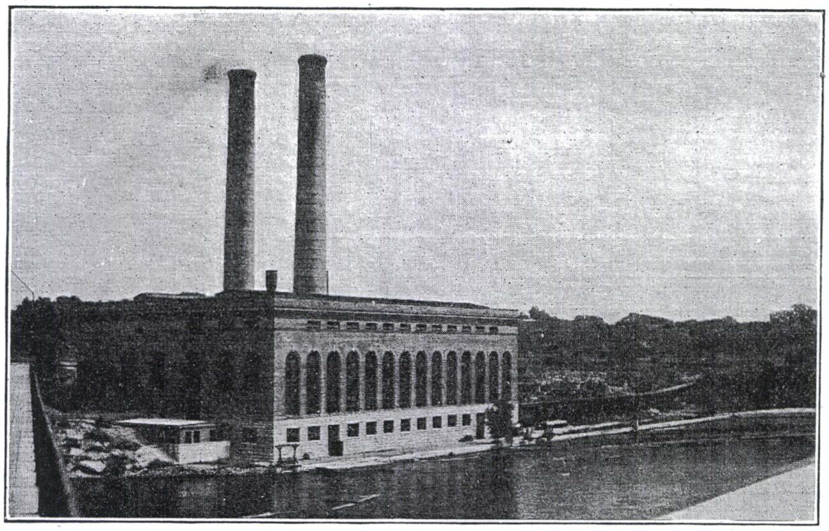
The rotary converter room is served by a 20-ton motor hoist hand travel Whiting crane.

Messrs. Sargent & Lundy, of Chicago, were the engineers for the new power station, and the entire electrical equipment of the sub-stations and the high-tension distribution system. All of the contracts for the work were let on their specifications and drawings. The design and arrangement of the main station were prepared by the engineers, and the architectural and structural steel drawings by Messrs. E. C. and R. M. Shankland, of Chicago. The architectural work on the sub-stations and the general design, aside from the electrical equipment, were by Mr. C. F. Ferrin, of the Twin City company.

The construction and installation were carried out under the superintendence of the mechanical and electrical departments of the Twin City company, which are in charge of Mr. E. H. Scofield, electrical engineer, and Mr. D. W. Dozier, chief engineer of power stations.

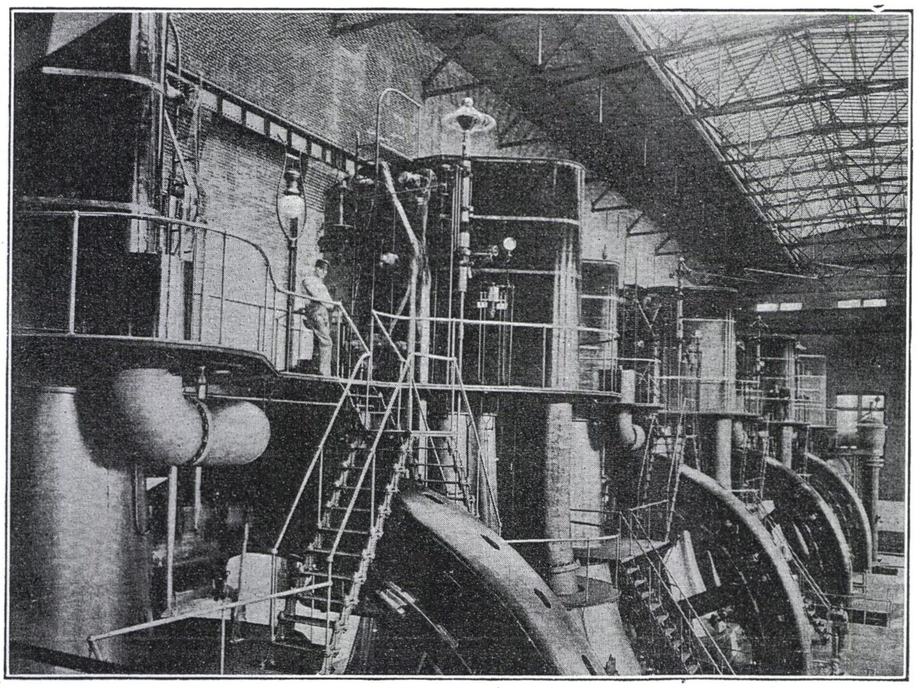
For data and illustrations we wish to make special acknowledgment to Mr. Scofield, to Mr. W. S. Monroe and Mr. F. Woodmansee, of Sargent & Lundy, and to Westinghouse, Church, Kerr & Co.

THE STEAM POWER STATION OF THE TWIN CITY RAPID TRANSIT COMPANY, MINNEAPOLIS



THE MINNEAPOLIS POWER PLANT OF THE TWIN CITY RAPID TRANSIT COMPANY

The steam-driven electrical generating station of the Twin City Rapid Transit Company, of Minneapolis, has a normal rated capacity of 35,000 hp and an overload capacity of 50,000 hp. The generating equipment of this station is operated in parallel with the equipment of a 10,000-hp hydro-electric station which is approximately 1000 ft. distant. The two stations furnish power to ten electric sub-stations in St. Paul and Minneapolis and in the adjacent towns, the maximum distance of transmission being about 25 miles. The generating equipment of the two stations delivers three-phase alternating current at 13,200 volts which rotary converters in the sub-stations transform to direct current at 600 volts. Each power station supplies about one-half the total requirements in kw-hours, the steam station taking the variations in the load, as shown on the typical load curve on page 127.



INTERIOR OF ENGINE ROOM FROM THE SWITCHBOARD GALLERY

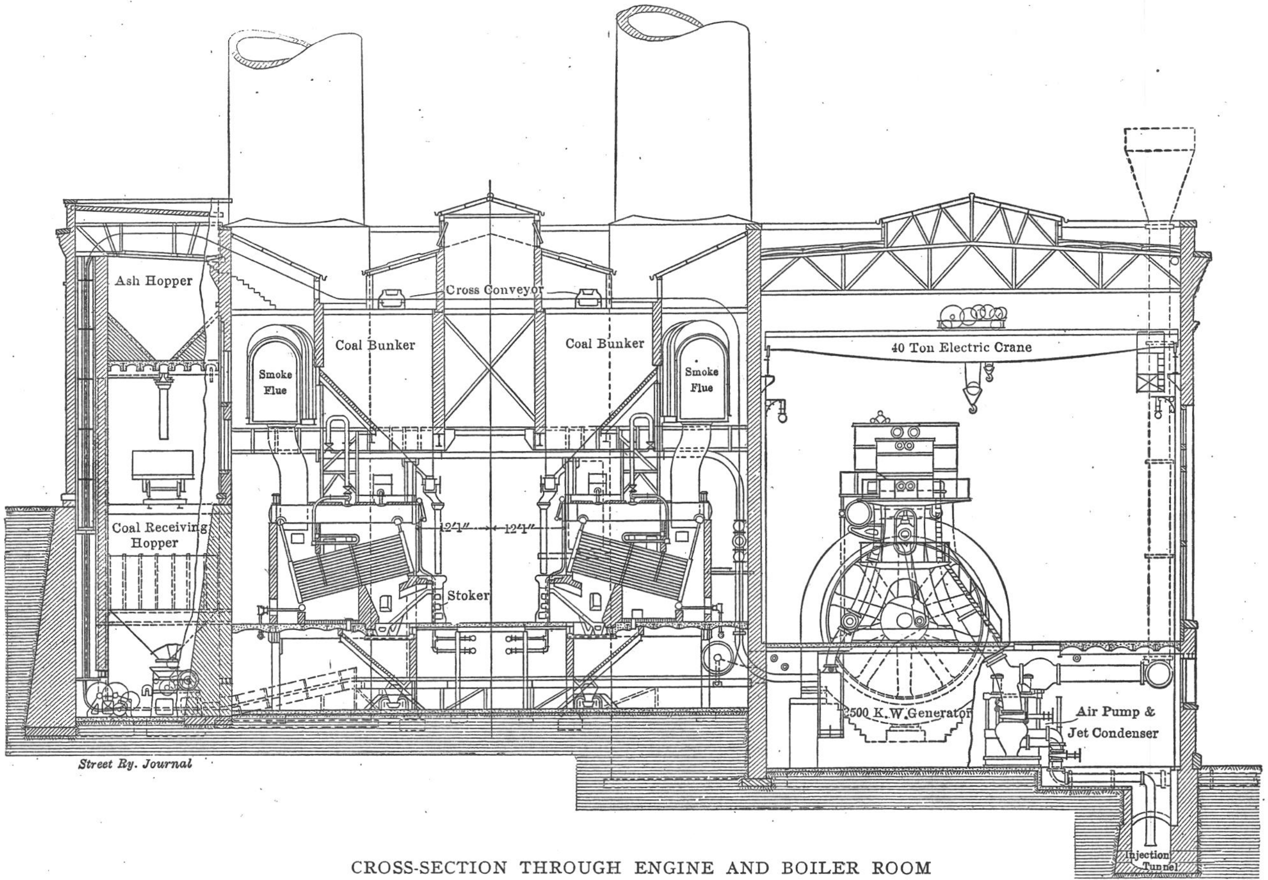
The steam power station is on the east bank of the Mississippi River just below the flour mills in the center of the city. It is in a brick building, 155 ft. 11 ins. by 225 ft. in plan and 93 ft. in height from the floor of the engine room basement to the roof. A 12-in. longitudinal brick wall divides the building into a boiler room and an engine room. The boiler room is 83 ft. wide, the full length of the building, and has a clear height to the roof girders of 52 ft., a basement 14 ft. high extending under its full length. The engine room is 67 ft. wide, the full length of the building, its floor being 4 ft. lower than the boiler room floor. A basement 20 ft. high extends the full length of the building under the engine room.

The boiler room contains twenty-four 556-hp Babcock & Wilcox water-tube boilers, which are placed in two rows, with twelve boilers to the row. The fronts of the boilers in the rows face on a firing floor 14 ft. wide along the longitudinal center line of the room. The coal supply for the boilers is delivered to the station in cars on a switch which connects with the main line tracks of the Great Northern Railway. This switch extends the full length of the building close to the land side of the latter. Coal may be unloaded into a receiving hopper under the track and at one corner of the building, or on a 24-in. endless belt conveyor built by the Jeffrey Manufacturing Company, which extends the length of the building between the latter and the track and delivers coal to the receiving hopper. This conveyor is 205 ft. long from center to center of the coal pulleys, and when traveling at 280 ft. a minute has a capacity for handling 75 tons an hour. It is back-geared to a 10-hp General Electric motor, which is enclosed in a dust-proof steel case. The sideboards of the conveyor are 1½-in. oak plank attached to iron frames, those on the track side being built in sections which lean against the cars on the track and prevent coal falling under the latter as it is shoveled over the sides.

The receiving hopper at the end of the conveyor discharges into a single-drum McCaslin coal crusher in a room outside of one corner of the basement under the boiler room. Run-of-the-mine coal is generally received at the station and is all reduced by the crusher to pieces under

¾ in. in maximum dimensions. The crusher delivers to a conveying system which supplies coal to bunkers directly above the boilers.

This conveying system is of the McCaslin gravity-overlapping-bucket type. It is comprised of a transverse conveyor, at the same end of the building as the coal crusher, and two longitudinal conveyors, one serving the bunkers over each row of boilers. The transverse conveyor runs horizontally from the crusher room to the opposite side of the building, then up the side of the latter to the roof girders, back horizontally just under these girders to the crusher side of the building, thence up over an ash hopper, which is directly over the unloading track along the side of the building, and down vertically to the coal crusher again. The two longitudinal conveyors extend horizontally under fronts of the boilers the length of the basement beneath the boiler room, up at the opposite end of the building to the roof, back horizontally over the bunkers to the transverse conveyor and down again to the basement. The transverse conveyor carries the coal from the crusher to either of the longitudinal conveyors into which the coal is automatically discharged. These conveyors elevate and distribute the coal to the bunkers over the boilers. The transverse conveyor is driven by a 7½-hp, 600-volt, direct-current motor; each longitudinal conveyor is driven by a 25-hp, 600-volt, direct-current motor. The motors are at the bottom of the down-takes in all three conveyors, and the apparatus for taking up slack in the conveyors is at the bottom of the up-takes.



Street Ry. Journal

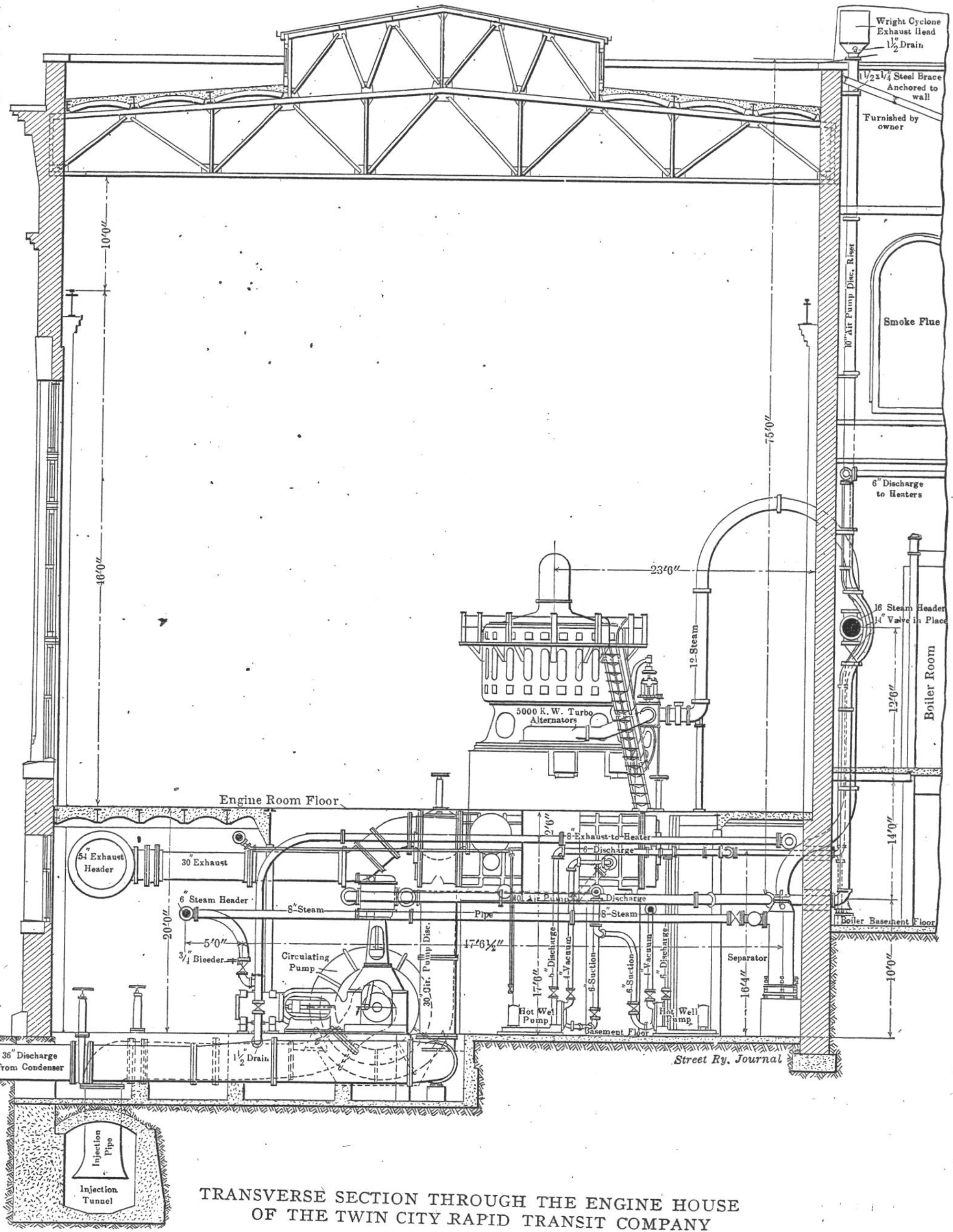
CROSS-SECTION THROUGH ENGINE AND BOILER ROOM

Four coal bunkers, with a combined capacity of 2800 tons, are provided. Two of these bunkers are over each row of boilers, each bunker supplying three batteries of two boilers. The bunkers are of cinder concrete and are carried by a structural-steel frame. They are placed so a light well, 14 ft. wide the full length of the boiler room, is obtained between them, giving good light and ventilation to the whole boiler room and particularly to the firing room floor. The bottom of each bunker has six steel hoppers, which lead through under-cut gate valves, controlled from the firing floor by hand chains, to spouts feeding the stokers with which the boilers are equipped.

The stokers are of the Roney automatic type, with engine-driven rocking inclined grates having 111 sq. ft. of heating surface each. The fire arch of the boiler furnaces has a single span. The ashes are discharged from the stokers into ash hoppers in the basement. These hoppers are built of steel and are lined with fire brick. The ashes are discharged from them through a gate at the bottom directly into the horizontal run of the longitudinal conveyors, the hoppers for one row of boilers being served by one conveyor and those of the other by the second. The conveyors elevate the ashes to the top of the building and discharge them into the upper horizontal run of the transverse conveyor, which carries them to the ash hopper over the unloading track along the building. This hopper is lined with cinder concrete and discharges at the bottom through a gate in a chute leading to cars on the track beneath it.

The boilers have a normal rated capacity of 556 hp each and a maximum capacity of 825 hp. They are operated at 180 lbs. pressure, and are equipped with Babcock & Wilcox superheaters, which are contained within the boiler settings just above the tubes of the boiler, and are capable of producing 100 degs. F. superheat. Each boiler has three steam and water drums, 36 ins. in diameter and 23 ft. 3 ins. long. The boiler tubes are of the wrought-steel sectional type, 4 ins. in diameter and 18 ft. long, and are in twenty-one sections, of 13 tubes each, to the boiler. The total heating surface of each boiler is thus 5560 sq. ft., or 10.5 sq. ft. of heating surface to each square foot of grate area. Each row of boilers is served by an Alphonse Custodis hollow, radial molded brick stack, 162 ft. high and 16 ft. inside diameter. These stacks are placed on the transverse center line of the boiler room and are carried 63 ft. above the floor of that room, so they have a total height of 220 ft. above the furnaces. A smoke flue extends in both directions from each stack well above the settings of the boilers, the connection of each of the latter to these flues being made through a short vertical breeching.

The water supply of the station is taken from the river and is handled by four service pumps in the basement of the engine room. Owing to the presence of an objectionable amount of foreign matter in the river water all of the water used in the station is passed through a rapid sand filter plant built by the Norwood Engineering Company. This plant is in a detached brick building, 35 ft. 4 ins. x 48 ft. 8 ins. in plan, which has a concrete sub-structure and is at the upstream end of the main station building. Two horizontal simplex low-pressure Blake steam pumps, with a capacity of 600 gals. each, deliver water from the river or hot-well of the condensers to the filter plant.


Wright Cyclone Exhaust Head
1½" Drain
1½ x 1¼ Steel Brace Anchored to wall
Furnished by owner
10'0"
10" Air Pump Disc. Riser
Smoke Flue
75'0"
6" Discharge to Heaters
23'0"
12" Steam
16 Steam Header
14" Valve in Place
5000 K. W. Turbo Alternators
46'0"
12'6"
Boiler Room
Engine Room Floor
2'6"
8" Exhaust-to-Heater
6" Discharge
14'0"
54" Exhaust Header
30" Exhaust
10" Air Pump
Discharge
6" Steam Header
8" Steam
Pipe
8" Steam
Boiler Basement Floor
20'0"
5'0"
¾" Bleeder
Circulating Pump
30" Cir. Pump Disc.
17'6½"
17'6"
6" Discharge
4" Vacuum
6" Suction
6" Suction
4" Vacuum
6" Discharge
Separator
16'4"
10'0"
Hot Well Pump
Hot Well Pump
Basement Floor
36" Discharge from Condenser
1½" Drain
Street Ry. Journal
Injection Pipe
Injection Tunnel

TRANSVERSE SECTION THROUGH THE ENGINE HOUSE OF THE TWIN CITY RAPID TRANSIT COMPANY

The discharge from these pumps is an 8-in. pipe, which is controlled by a butterfly valve, and has its outlet in a sedimentation basin, 24 ft. x 33 ft. in plan and 17 ft. deep, within the filter building. When necessary, sulphate of alumina is applied to the raw water to assist in the removal of impurities. A sedimentation period of one and one-half hours is provided in the basin when the plant is operating at full capacity, and the basin is provided with baffles, so the coagulant has an opportunity to become flocculent and to mix well with the water. The plant contains four filter beds, which are each 10 ft. x 13 ft. in plan, and have a combined capacity of 1200 gals. per minute. The filters contain 8 ins. of gravel, in three sizes, at the bottom, and then 28 ins. of sand. They are equipped with the usual strainer drainage and air wash systems. A 6-in Lawrence centrifugal pump, operated by a 20-hp motor, provides water for washing the filters, and an 8 in. x 12-in. air compressor driven by a pulley on the pump shaft furnishes air for agitating the sand during washing. A clear water well located under the filter beds forms a suction well for the other two service pumps.

This filter plant has been in service for a year and has proved to be particularly valuable in removing impurities from the raw water. The river is turbid at times and generally contains a considerable amount of raw sewage at the station; it also carries a large amount of bark produced from the numerous wood-working industries above Minneapolis. The water from the hot-well is condensed steam from the engines and contains more or less oil. These various foreign matters are so completely removed by the filter plant that very little trouble is experienced with the boilers from the feed-water.

The two service pumps which draw from the clear well of the filter plant are of the Dean Bros. horizontal, duplex, double-acting type, and have a capacity of 1200 gals. each. These pumps deliver to the feed-water heaters.

Two open feed-water heaters, with a capacity of 350,000 gals. per hour each, are installed in the boiler room, one in each of the two spaces in front of the stacks. One of these heaters was built by the Stillwell-Bierce & Smith-Vaile Company and the other by the Platt Iron Works. They both have a 12-in. steam inlet and an 8-in. steam outlet; their water supply lines are 8 ins. in diameter and are provided with a regulating valve.

Six pumps supply water to the boilers from the feed-water heaters. Four of these are marine, vertical, double-acting, twin Dean Bros. pumps, with a normal capacity of 300 gals. per minute; the other two are Admiralty pattern, pot valve, vertical duplex Worthington pumps, each with a normal capacity of 600 gals. per minute. Two independent headers are supplied from the pair of Worthington pumps and two from the pair of twin Dean Bros. pumps, cross connections being made between the two corresponding pipes of the two sets of lines. These headers are in the basement immediately under the firing room floor, each boiler having a separate connection to two of them. The feed-water pumps are also connected so they can supply either hot or cold water to each header system.

A main live-steam header, 16 ins. in diameter, extends along the wall which separates the boiler room from the engine room. This header is in two sections, one on each side of the stack serving the row of boilers on that side. These sections are connected by a 14-in. loop with cut-off valves at each end. An 8-in. auxiliary header, with connections to the service pumps, air pumps and a steam-driven exciter unit in the engine room, is also provided. A battery of two boilers from each row is coupled with the battery across the firing floor from it and a 12-in. steam connection with the 16-in. header is provided for each of these sets of four boilers. This connection is reduced to 10 ins. in diameter from the first to the second battery. Each boiler of the set of four has a 7-in. connection with the main, connecting the set with the header. Two cut-off valves are provided on each of these 7-in. connections, and a cut-off valve is placed in each 12-in. connection at the header. Cut-off valves in the latter also provide for operating independently any one of the units in the engine room with steam from four boilers.

The engine room contains six main units, four reciprocating engines direct connected to engine generators, and two turbo-generator units. The four reciprocating units comprised the original installation in the engine room; the two turbine units are not yet quite ready for service, although they are installed. The original units have vertical cross-compound condensing 46 in. and 94 in. x 60-in. Allis-Chalmers engines without fly-wheels. These engines have a normal rated capacity of 500 ihp, with a steam consumption of 11½ lbs. per ihp-hour, the steam being at 175 lbs. gage pressure and 75 degs. F. superheat, and the engine exhausting into 26 ins. of vacuum and operating at 74¼ r. p. m. Under these same conditions the engines have a rated maximum capacity of 9000 ihp when running at 73 r. p. m. The engines are equipped with the Reynolds-Corliss valve gear having an automatic weighted governor operating both the high and low-pressure sides. The steam supply and exhaust valves are operated by separate eccentrics; the speed control is operated by a motor controlled from the switchboard. Each of these engines occupies a floor space of 17 ft. x 36 ft., and has an approximate height of 36 ft.

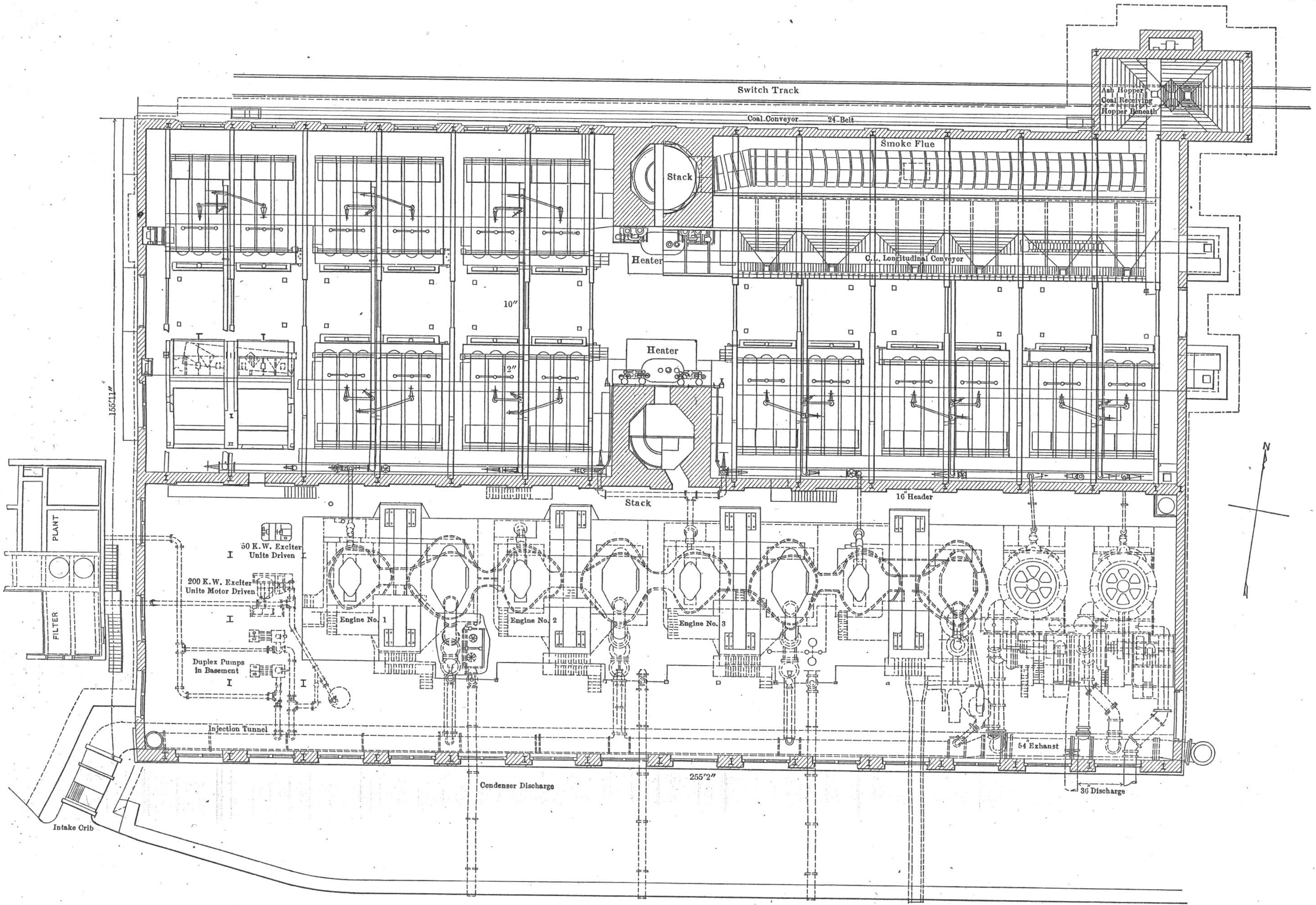
A three-phase, 35-cycle revolving-field fly-wheel type General Electric generator, capable of producing 3500 kw at 13,200 volts, is direct connected to each of the main engines. The revolving field of each generator is equivalent to a fly-wheel weighing 308,000 lbs at a radius of gyration of 12.2 ft. These generators each occupy a floor space of 8 ft. x 24 ft., and have an approximate height of 34 ft.

Three of the main engines are each provided with a vertical, twin, beam-connected 18-in. and 48-in. x 24-in. Blake air pump and jet condenser having a single-acting air end and a double-acting steam end. The pumps of these condensers draw from a 6-ft. x 8-ft. injection tunnel which extends from an intake in the river at the upstream end of the building under the engine room basement along the river side of the latter to the downstream end of the building. The cooling water is discharged from each condenser directly into the river.

The fourth engine is equipped with an Allis-Chalmers barometric-type condenser with the condenser chamber attached to the engine cylinder. This condenser has two barometric columns, one 16 ins. in diameter for the removal of both air and water, and one 20 ins. for an overflow. Cooling water for the condenser is supplied by a 20-in. centrifugal pump driven by a Ball engine.

These four engines are also arranged with 30-in. connections to a 42-in. free exhaust header in the basement of the engine room, a relief valve being placed in each of these connections. This header extends the full length of the basement and connects at each end with a riser leading to an exhaust head above the roof. The part of the header adjacent to the turbines is increased to 54 ins. in diameter. A 12-in. auxiliary exhaust header is also provided for the feed-water heaters, and has a 5-in. riser extending to an exhaust head above the roof. The condenser engines and the feed-water pumps exhaust into the feed-water heaters, and the stoker engines exhaust under the grates.

The noteworthy feature of the whole station is the fact that the two turbines having a combined normal rated capacity of 10,000 kw occupy the space originally provided for one 3500-kw reciprocating unit, although the turbine auxiliaries are somewhat crowded in the basement. The two turbine units are of the five-stage Curtis type, mounted on a base condenser; each of them is direct coupled to a six-pole, delta-connected, three-phase, 35-cycle, 13,200-volt, alternating-current General Electric generator producing 5000 kw at 700 r. p. m. The steam consumption of these units, with steam at 175 lbs., 2 ins. absolute back pressure and 100 degs. F. of superheat, is guaranteed to be 18.3 lbs. per kw-hour at half load; 17 lbs. at full load; 17.5 lbs. at 50 per cent overload and 17.8 lbs. when the load varies between 50 per cent and 150 per cent of the full load. Each unit is controlled by a centrifugal governor, which mechanically operates a poppet type valve in the steam supply line, the variation in speed from no load to full load being guaranteed not to exceed 2 per cent, except that a sudden change in load may cause 4 per cent momentary variation.


Switch Track
Ash Hopper
Coal Receiving
Hopper Beneath
Coal Conveyor
24 Belt
Smoke Flue
Stack
Heater
C.L. Longitudinal Conveyor
10″
12″
Heater
155′11″
Stack
16″ Header
PLANT
FILTER
50 K.W. Exciter
Unite Driven
200 K.W. Exciter
Unite Motor Driven
Duplex Pumps
in Basement
Engine No. 1
Engine No. 2
Engine No. 3
Injection Tunnel
54″ Exhaust
255′2″
Condenser Discharge
36″ Discharge
Intake Crib
Street Ry. Journal

GENERAL PLAN OF THE TWIN CITY RAPID TRANSIT COMPANY'S POWER STATION

The step bearing of the turbine is supplied with 12 gals. of oil a minute under a pressure of 550 lbs. per square inch. The piping system which supplies oil to these bearings is furnished with pressure by two twin Worthington steam pumps, which are connected in relay so in case one pump fails to maintain the required pressure the second will start. A hydraulic accumulator built by R. D. Wood & Company is connected with this piping system to maintain the pressure on the latter. This accumulator has an 8-in. ram with an 8-ft. stroke, and is weighted to produce a working pressure of 550 lbs. A motor-driven triplex pump is also provided as an auxiliary to the steam pumps, and is started automatically if the accumulator falls below the predetermined height. A separate pump and system of piping supplies oil at 80 lbs. pressure for the governors, steady bearings and general lubrication of the turbines. The discharge from the step bearings and governors flows into closed settling tanks, the pumps drawing from these tanks. The water, sediment and dirty oil are drawn from the bottom of the tanks and passed through two Turner filters.

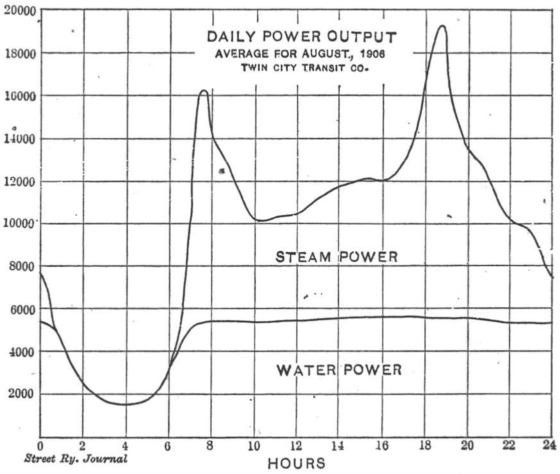
The base condenser of each turbine has 20,000 sq. ft. of surface in brass tubes having an outside diameter of 1 in. The cooling water for each condenser is drawn from the injection tunnel under the basement floor by a 30-in. special volute centrifugal pump with an enclosed impeller. The maximum amount of water required is 18,000 gals. a minute. A vertical 20-in. x 24-in. dry vacuum pump, fitted with a Cincinnati air valve gear controlling the three constant points in the compression cycle, namely, the opening of the suction, the closing of the suction and the closing of the discharge, is provided for each unit. This pump and the centrifugal pump for circulating cooling water are direct connected to a four-valve, 19 in. x 24-in. horizontal Corliss engine. A 4-in., two-stage horizontal turbine pump direct connected by a flexible coupling to a 20-hp, 550-volt, direct-current motor is provided for lifting condensed steam from the bottom of the condenser to the feed-water heater.

One engine-driven and two motor-driven exciter sets are installed in the engine room. The engine-driven set has a 50-kw, six-pole, shunt-wound, direct-current generator coupled to a 11-in. x 11-in. vertical, single-cylinder engine having a piston valve and automatic fly-wheel governor. The motor-driven sets each have a 200-kw, eight-pole, shunt-wound, direct-current generator direct connected to a 300-hp induction motor, the sets operating at 520 r. p. m.

The switchboard from which the operation of the equipment of the engine room is controlled is on a gallery 31.5 ft. above the floor at the end of the room farthest from the turbine units. This switchboard has twenty-nine panels of blue Vermont marble, all of the instruments having a marine finish. The arrangement of this switchboard will not be described in detail here. The general system of high-tension connections, however, is as follows: The 13,200-volt current from the generators is conveyed by three-phase cables to the generator oil switch, to disconnecting oil switches and to bus-bars. The latter are divided into three sections by means of oil switches. All incoming and outgoing lines are three-phase cables. Current to outgoing lines is conveyed from the bus-bars through disconnecting switches, an oil switch and disconnecting switches, in order. In case two or three cables supply a sub-station, they are connected on different sections of the bus-bars. Static arresters are installed on outgoing and incoming lines to relieve any heavy electrical strains. The grounding of any cable is shown by a Westinghouse static detector. Any piece of high-tension apparatus can be disconnected in order to make repairs or for inspection and cleaning.

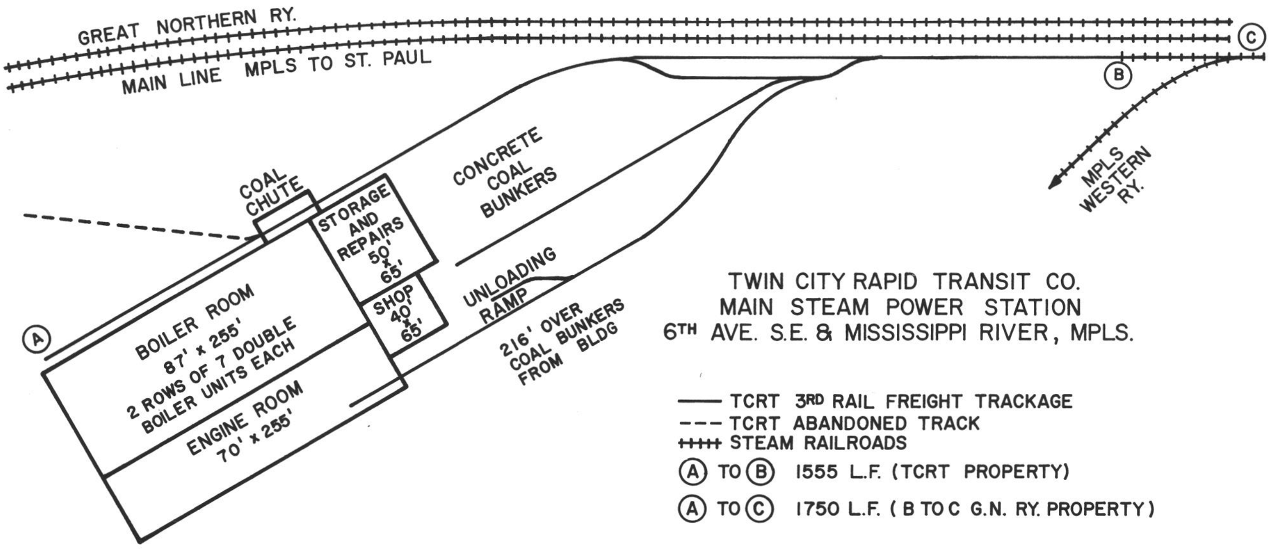
The engine room is served by an electrically-driven traveling crane having a span of 65 ft., a 40-ton main hoist and a 5-ton auxiliary hoist. This crane has a vertical lift of 60 ft., and was built by the Whiting Foundry Equipment Company.

The steam power plant was designed and built and is operated under the direction of E. H. Scofield, chief engineer of the Twin City Rapid Transit Company, of Minneapolis. Sargent & Lundy, electrical and mechanical engineers, of Chicago, were consulting engineers to that company during the preparation of the plans and the construction of the station.



TWIN CITY DAILY STEAM AND WATER-POWER CURVES

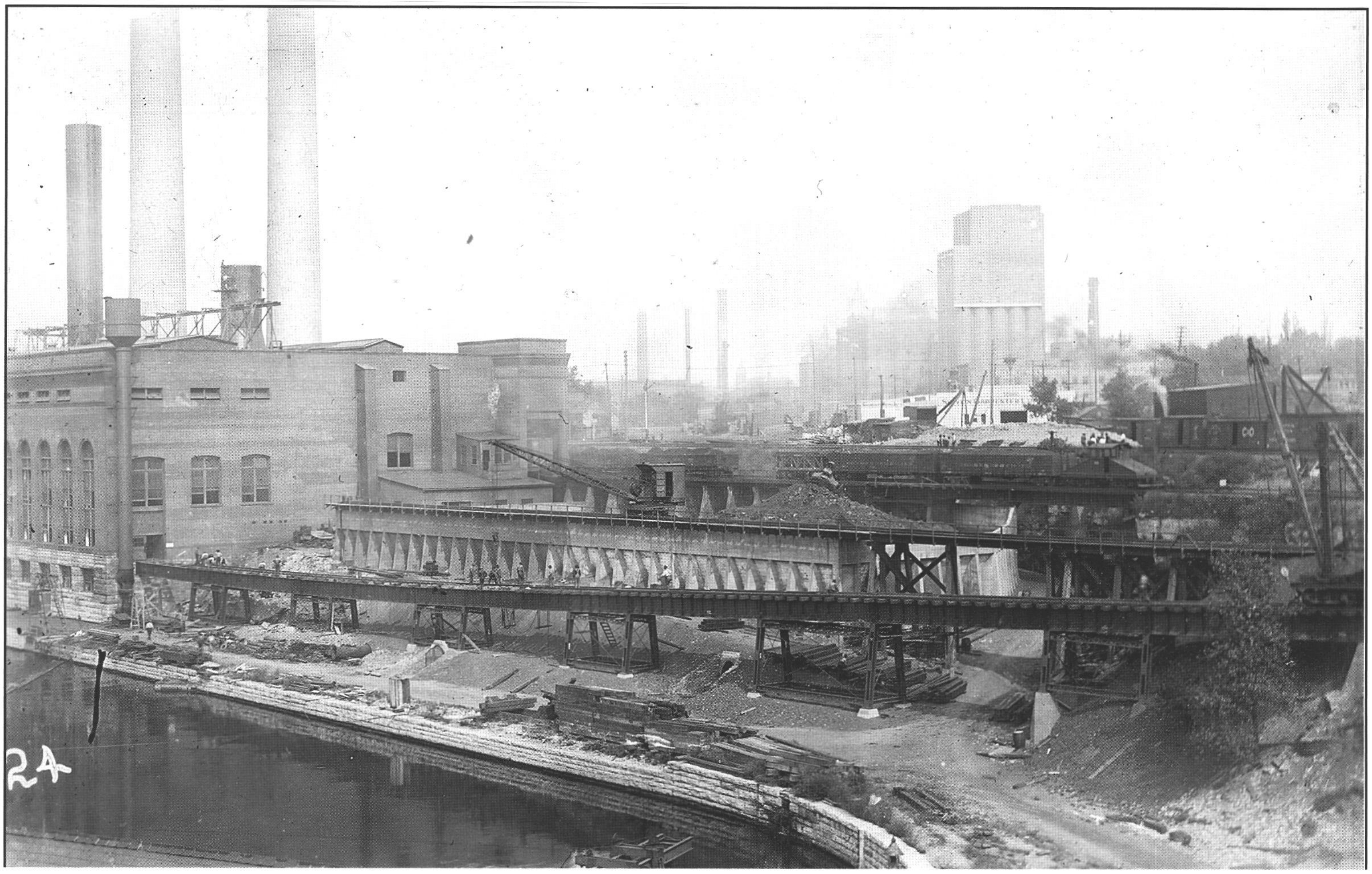
◆


GREAT NORTHERN RY.
MAIN LINE MPLS TO ST. PAUL
Ⓒ
Ⓑ
MPLS WESTERN RY.
CONCRETE COAL BUNKERS
COAL CHUTE
STORAGE AND REPAIRS 50' x 65'
SHOP 40' x 65'
UNLOADING RAMP
216' OVER COAL BUNKERS FROM BLDG
Ⓐ
BOILER ROOM 87' x 255' 2 ROWS OF 7 DOUBLE BOILER UNITS EACH
ENGINE ROOM 70' x 255'
TWIN CITY RAPID TRANSIT CO.
MAIN STEAM POWER STATION
6TH AVE. S.E. & MISSISSIPPI RIVER, MPLS.
—— TCRT 3RD RAIL FREIGHT TRACKAGE
- - - TCRT ABANDONED TRACK
+++++ STEAM RAILROADS
Ⓐ TO Ⓑ 1555 L.F. (TCRT PROPERTY)
Ⓐ TO Ⓒ 1750 L.F. (B TO C G.N. RY. PROPERTY)

Track highlighted in yellow appeared on a 1907 map.

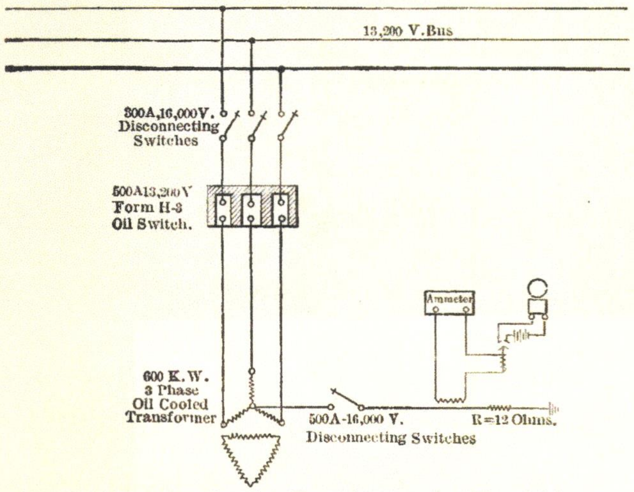
April 1910: machinery spur track and steel trestle built.

1912: new spur track and steel trestle built.



GROUNDING A TRANSMISSION SYSTEM THROUGH A SPECIAL TRANSFORMER

Current for the operation of the Twin City Rapid Transit Company's lines is generated at a large steam station and two water-power stations. The machines in the older one of the water-power stations generate current at 3500 volts, while the steam station and the new water-power station feed the transmission system at the generating pressure of 13,200 volts. The step-up transformers in the old water-power station which raise the voltage from 3500 to the generating and transmitting pressure of the other stations, are delta-connected on both secondary and primary. During the part of the day when the lightest load occurs this station has ample capacity to furnish current for the entire railway system, and therefore the steam station may be shut down. Since the transformers in the old water-power station are delta-connected, it has not been possible until recently to have ground connection on the transmission system while this station is carrying the whole load. To furnish a permanent ground for the entire high-tension system a large transformer with its primary coils star-connected and its neutral grounded through resistance has been installed in the steam generating station. The transmission cables to the substations all radiate from the bus compartments of this station and by means of the grounded neutral of this transformer there is a ground connection for the transmission system, no matter which of the generating plants may be in service.



Connections for Special Transformer for Furnishing a Ground to the Twin City Transmission System

The accompanying sketch shows the arrangement of the grounding transformer and its connection with the main high-tension bus of the distributing station. The transformer is of the standard self-cooling type of 600-kw capacity, with the primary coiil star-connected and wound for 13,200 volts and the secondary coil delta-connected and wound for 440 volts. The secondary coil is permanently connected in delta with no exterior taps. Were this secondary to be opened the transformer would act only as impedance in the three-phase circuit. The frequency is 35 cycles.

The primary leads of the transformer are connected with the main high-tension buses of the power station through a form H-3 oil switch provided with hand-operated disconnected switches. The oil switch is provided with operating contacts on the switchboard, but no automatic relay is connected in the control circuit. The midpoint of the star-wound primary is connected to ground through a disconnecting switch and a cast-grid resistance of 12 ohms. This amount of resistance restricts the current flowing to ground to a maximum of about 600 amp when there is a good ground on any other point in the high-tension system. A current transformer is interposed in the ground lead between the disconnecting switch and the resistance. This current transformer operates the coil of a relay, which is so adjusted that when current to the amount of 40 amp passes through the ground connection the plunger of the relay completes a bell circuit, thus giving an alarm. The relay adjustment is such that when the bough of a tree switches across the transmission line during a storm, or a bird gets in contact with the two sides of the horn arrester, the bell immediately rings. Double ground connections were made by sinking a plate below the water level of the river nearby and by making connection to the negative return cables of the railway system.

The installation of this large transformer for the purpose of grounding the neutral of the three-phase transmission system has been successful. Previous to the time when this transformer was put into service surges occurred on the transmission system, which resulted in troubles to the cable insulation being communicated from one point of the transmission network to widely varying points. Ordinarily such troubles originate because of a ground rather than a short circuit, and now, when such a ground occurs, the alarm bell operated from the ground connection of the transformer immediately notifies the switchboard attendant that there is trouble on some feeder line. He at once glances along the line of ammeters and can tell by the swinging of the needles which feeder is disturbed. The oil switch between this feeder and the main bus immediately is opened and thus the trouble is not communicated to the substations; and so far the operators have been able to open feeder lines on which the cables were grounded before the burning at the ground has become disastrous.

Practically the entire load on the transmission system consists of rotary converters, so the phases are balanced. All feeder lines leaving the power station have current transformers on each leg, so that no matter what phases become grounded the entire feeder is automatically cut out. The grounding transformer supplements this system of automatic overload relays and with the assistance of the switchboard operator defective cables are cut out before the short circuit or ground draws enough current to operate the automatic relays. It is stated that since this transformer installation has been in service there has not been a single case of "simultaneous" cable troubles.

◆

PROPOSED EXTENSIONS IN MONACO

Important extensions are proposed to the electric tramway system in Monaco, which has recently been taken over by the Nice-Littoral Tramway Company. Through connections have already been made between Nice and Mentone, by way of Monte Carlo, and the line will be extended to the Italian frontier, constituting one of the longest interurban lines in Europe. Further extensions are proposed in Italy by an Italian company, which eventually, it is reported, will connect Nice with Turin. It is already possible to travel by trolley a distance of about 50 miles, and nearly all of the way close to the seashore, through a scenery which has made the Riviera famous. Express trains are being run on part of the system, and there are branch lines to different points.

6-4-1910

~~saws of woodworking tools, etc. The parts of the machines which must be protected are usually painted red. Luncheon, including the inevitable beer, is supplied to the employees at cost prices by the company~~.

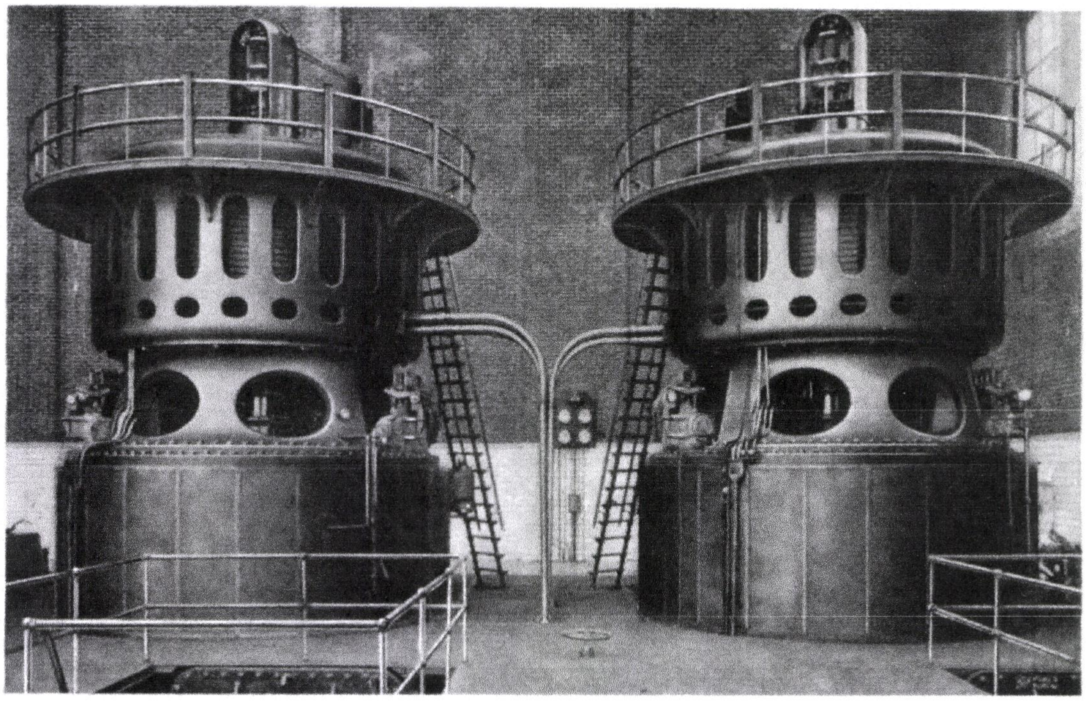
◆

POWER STATION ADDITIONS OF THE TWIN CITY RAPID TRANSIT COMPANY

The main generating station of the Twin City Rapid Transit Company originally was built to accommodate five marine type engines driving generators with a combined maximum capacity of 22,000 kw. This station has been described in these columns and as previously stated, in place of installing the fifth vertical engine, two 5000-kw Curtis turbines were installed. Now additions are under way and a 14,000-kw Curtis turbine is on order and will replace one of the present vertical units. The company plans ultimately to replace all four of the engine units with large turbines. These changes in generating units have required additions to the boiler plant and these changes are now being made. In addition, the two 5000-kw Curtis turbines are being equipped with forced ventilation which will raise their capacity to 8000 kw. each. Air will be taken from outside of the power house and circulated by a Sirocco blower driven by a Kerr turbine supplying 55,000 cu. ft. of fresh air per minute. Two circulating ducts are built around each generator frame and by means of these ducts cooling air is forced into the top and bottom openings in the sides of the frames. The heated air will escape through the series of openings around the middle of the frame. It is planned to furnish cooling air on the basis of 3 cu. ft. per minute per kilowatt. This change and the replacement of the engines by large turbines will give this station an electrical generating capacity of 58,000 kw in contrast with a maximum capacity of 22,000 kw for which the plant was originally designed.

In the boiler plant four new boilers with new feed pumps are being installed. All the boilers are being equipped with B. & W. chain grates and four steel stacks are being erected. The two old stacks were located at the center of the boiler house; the four new stacks will be located at the quarters of the building and supported on structural steel work spanning two boilers. Each new stack is to be 265 ft. high above the floor of the boiler-room and have an internal diameter of 14 ft. The supporting steel work has for its main members all four structural steel columns which are carried on foundations with a spread of 22 ft. x 30 ft. built upon solid rock. The two old stacks will be taken down and thus room will be afforded in the center of the boiler house for four more boilers. The present smoke flues which lead from the ends of the rows of the boilers to the old stacks in the center will be utilized, but the direction of flow of the gases will be reversed and the passage will be only half of its former length.

◆

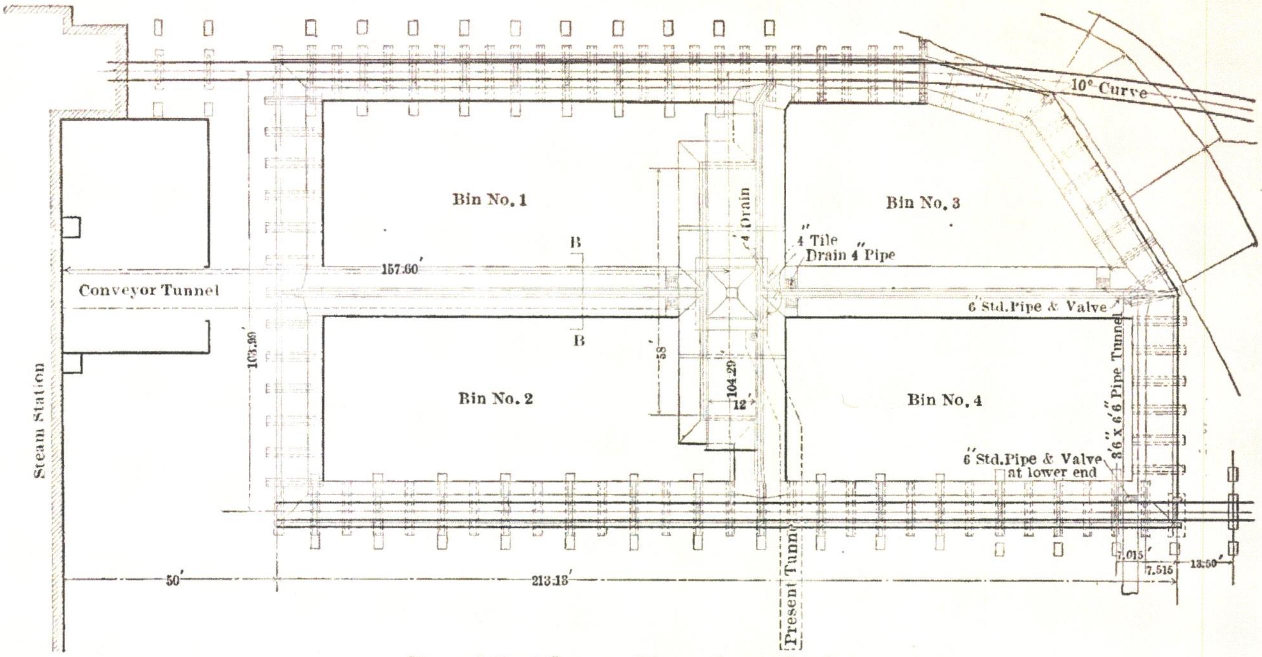


5000 Kw. Curtis Steam Turbine-Generator Installed for the Twin City Rapid Transit Co., Minneapolis, Minn.

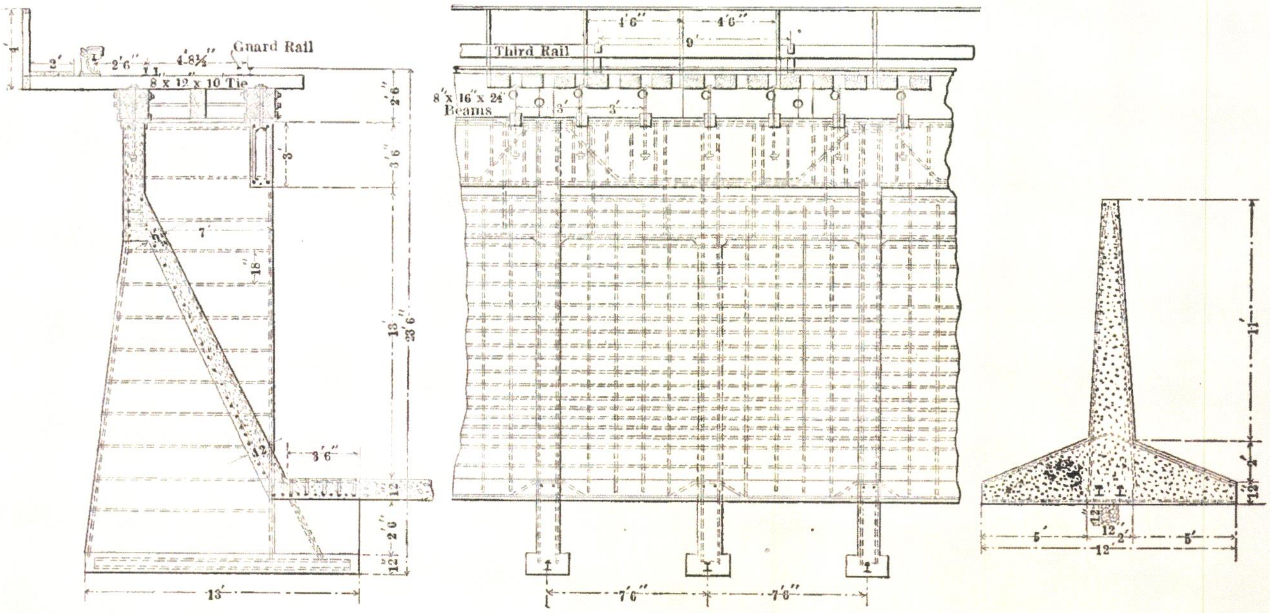
(ATB 6-5000-750, 13200 Volts)

BINS FOR SUBMERGED COAL STORAGE AT MINNEAPOLIS

The Twin City Rapid Transit Company has just completed the construction of a group of four coal bins which will permit the storage under water of 12,000 tons of coal. These bins are located 50 ft. distance from the boiler house of the main steam station of the company. The accompanying drawings show the principal construction features of the new coal bins. At Minneapolis it is possible to get an ample supply of screenings from December to April, but in the summer the supply is interrupted and therefore coal must be stored in the winter for summer use. With the new storage arrangement and provision for submerging the fuel it will be possible to accumulate enough screenings during the winter to run the plant in the summer. In this connection it should be noted that the steam generating station of the Twin City Rapid Transit Company operates in parallel with two nearby water-power stations which can carry a considerable part of the load during the summer.


Bin No. 1
Bin No. 2
Bin No. 3
Bin No. 4
Conveyor Tunnel
Steam Station
4" Drain
4" Tile Drain 4" Pipe
6" Std. Pipe & Valve
6" Std. Pipe & Valve at lower end
8'6" x 6'6" Pipe Tunnel
10° Curve
Present Tunnel
157.60'
163.90'
104.20'
58'
12'
50'
213.18'
7.515'
13.50'
B
B

Plan of Coal Storage Bin at Steam Station


Guard Rail
8 x 12 x 10 Tie
Third Rail
8" x 16" x 24' Beams
4'6"
4'6"
9'
2'
2'6"
4'8½"
3'
3'6"
18"
13"
23'6"
12"
13'
7'6"
7'6"
5'
12'
11'
2'

Section of South Trestle and Coal Storage Bin at Steam Station

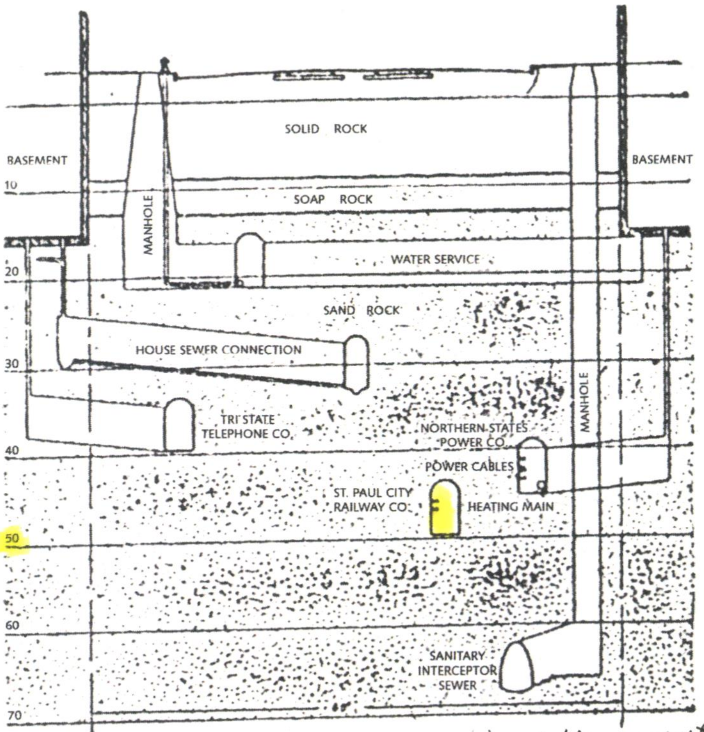
Briefly, the new coal-storage plant comprises rectangular-shaped bins with reinforced concrete walls and a reinforced concrete floor. The four bins are not interconnected. Each is watertight and is provided with intakes so that it may be filled from the bottom. At the center of the group of four bins is a hopper leading to a coal crusher from which the fuel is carried into the boiler house by a belt conveyor and there dumped onto the distributing conveyor which delivers it to the bunkers. Each of the two long sides of the storage bins is surmounted by a railway track supported on steel and concrete bents. Coal is received in hopper-bottom cars and dumped directly into the storage bins. A derrick car with a grab bucket also operated on these railway tracks is used to lift the coal from the bins into the central hopper leading to the crusher and the boiler-house conveyors. The tracks on which the derrick car operates are about 20 ft. above the floor level of the bins.

Referring to the drawings it is noted that the four bins are formed by cross walls which subdivide a concrete structure 213 ft. long by 104 ft. wide. The center partition walls are 14 ft. high. Each of the four bins is a water-tight structure with a floor slab 12 in. thick reinforced with ½-in. square rods laid 24 in. on centers in both directions. The outside walls also are 12-in. thick and are reinforced by ⅞-in. and ½-in. rods spaced 16-in. apart horizontally and from 6 in. to 12 in. apart vertically. The side walls have a batter of 6 in. to the foot and are supported at the back by a series of reinforced concrete buttresses spaced 6 ft. and 7 ft. 6 in. on centers. The center division walls have reinforced concrete foundations 12 ft. wide. The division walls are 11 ft. high above the foundation reinforced longitudinally and vertically with ½-in. rods. The coal tracks above one side wall are supported by a structural steel trestle encased in concrete. The track on the other side is supported by concrete girders 12 in. x 36 in. in section heavily reinforced and spanning the buttresses and bents which brace the side wall. The track structure is the ordinary railway timber-deck type wih a 2-ft. walkway on one side.

The piping system for flooding the tanks is fed from the power house through a main which branches to terminate in a valve under gratings in each of the four bins. The pipe mains are carried in the concrete tunnel through which the coal-conveying belt operates. The central hopper leading to the coal crusher and the conveyor which carries the coal to the power plant is about 12 ft. square. Leading to this hopper are extension slides with extreme dimensions of 80 ft. x 12 ft. These slides are made of steel plate supported on concrete and steel columns. The hopper with its slides is protected from the coal by reinforced concrete walls connected with the central division walls. This hopper is so placed that coal can readily be dropped into it from the grab bucket operated by the locomotive crane on the trestle tracks along the sides of the coal bins.

Experience has shown that coal can be protected from spontaneous combustion without total submersion. When the bins are completely filled and water is forced into the bottom it is noted that the moisture climbs practically to the tops of the coal piles by capillary attraction.

◆



TYPICAL CROSS SECTION
UNDERGROUND AREA
ST. PAUL STREET

Cables supported on heavy iron frames.

Main Steam Station

Concrete Coal Storage Bin:

1 steel viaduct 164' 4¼" long

Viaducts and Trestles:

North Viaduct 102' long

3 deck-plate Girder spans on steel bents

Center Viaduct 121'6" long

4 deck-plate Girder spans on steel bents

Machinery Viaduct 408' long

13 deck-plate Girder spans on steel towered bents

Filter Plant

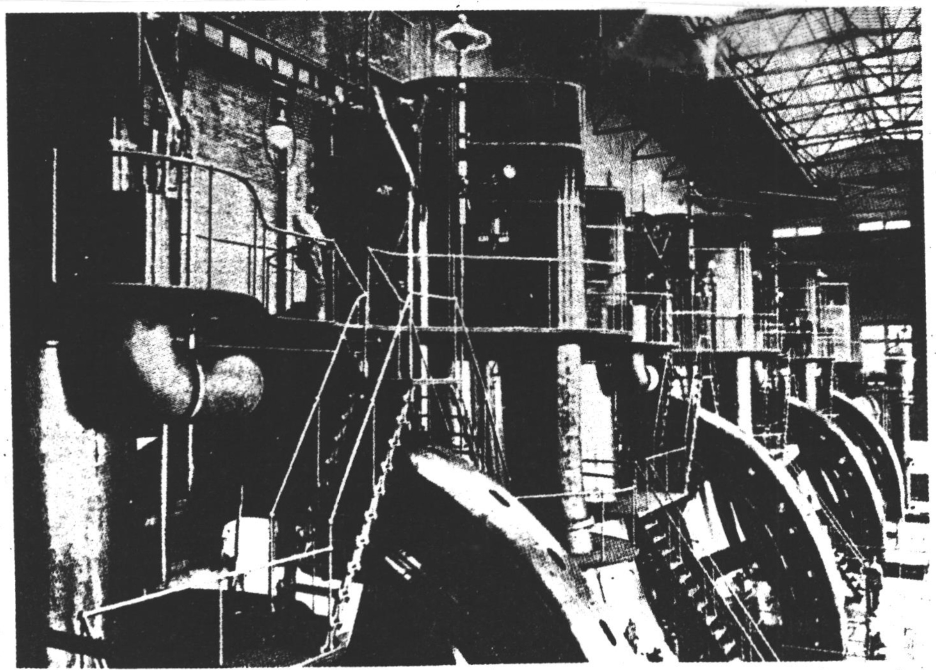
2 story brick and reinforced concrete

Machine Shop and StoreRoom east of steam station

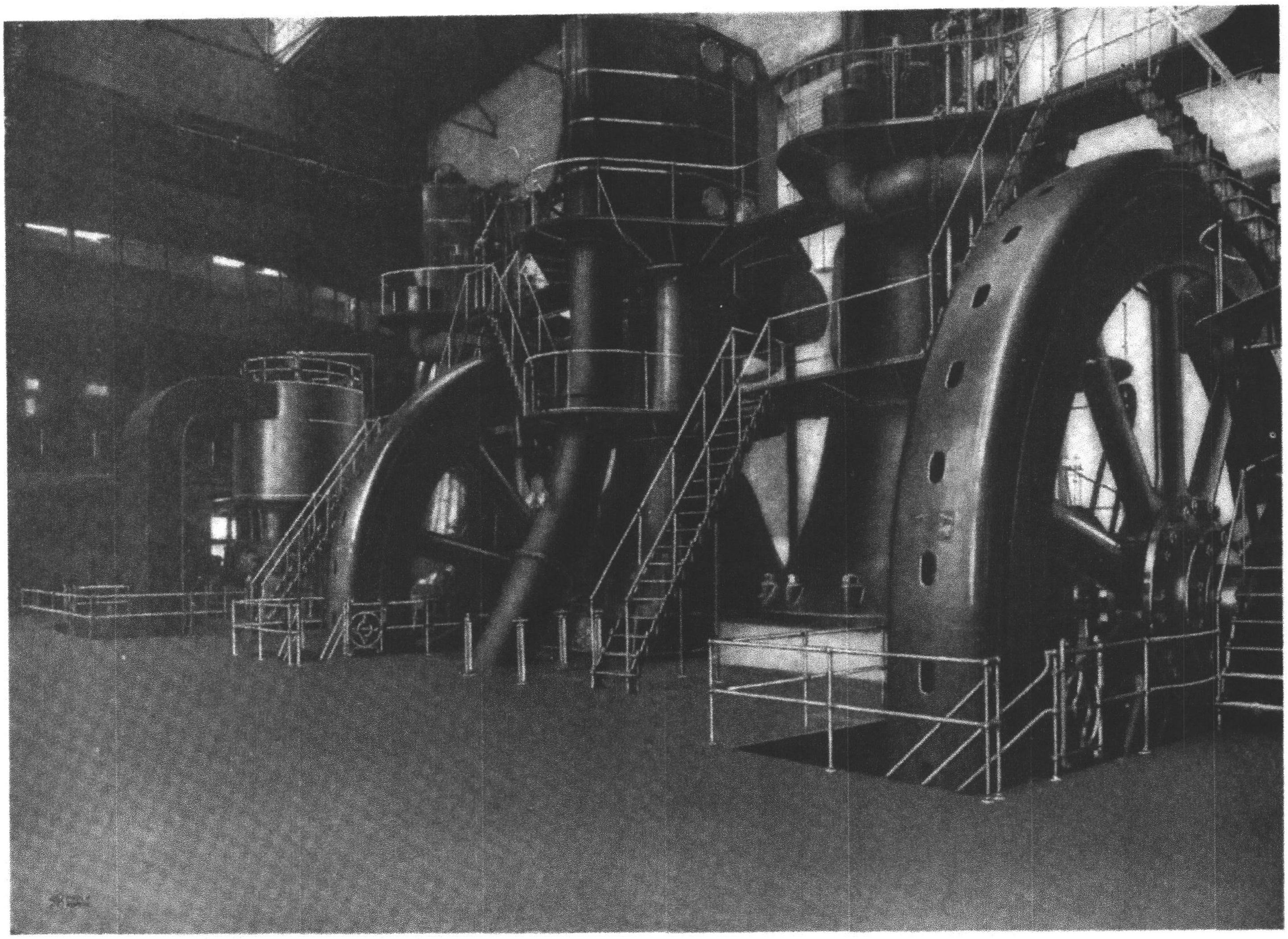
1 and part 2 story brick

Motor Room 6th Ave S.E. & the river

1 story brick



THIS PICTURE, taken in 1906, shows the 5,000 hp, triple expansion vertical Corliss engines driving 3,500 kw, 35 cycle generators, which were in the Twin City Rapid Transit company steam plant at Sixth Ave. S. E. and the Mississippi river.



Steam Power Plant, Twin City Rapid Transit Co., Minneapolis, Minn.

One 14,000 Kw. Curtis Steam Turbine Unit, Two 5000 Kw. Curtis Steam Turbine Units, Three 3500 Kw. G.E. Engine-Driven Generators

(The 14,000 Kw. Curtis Turbine Unit is Shown in the above Illustration)

POWER PLANT DEVELOPMENT IN MINNEAPOLIS

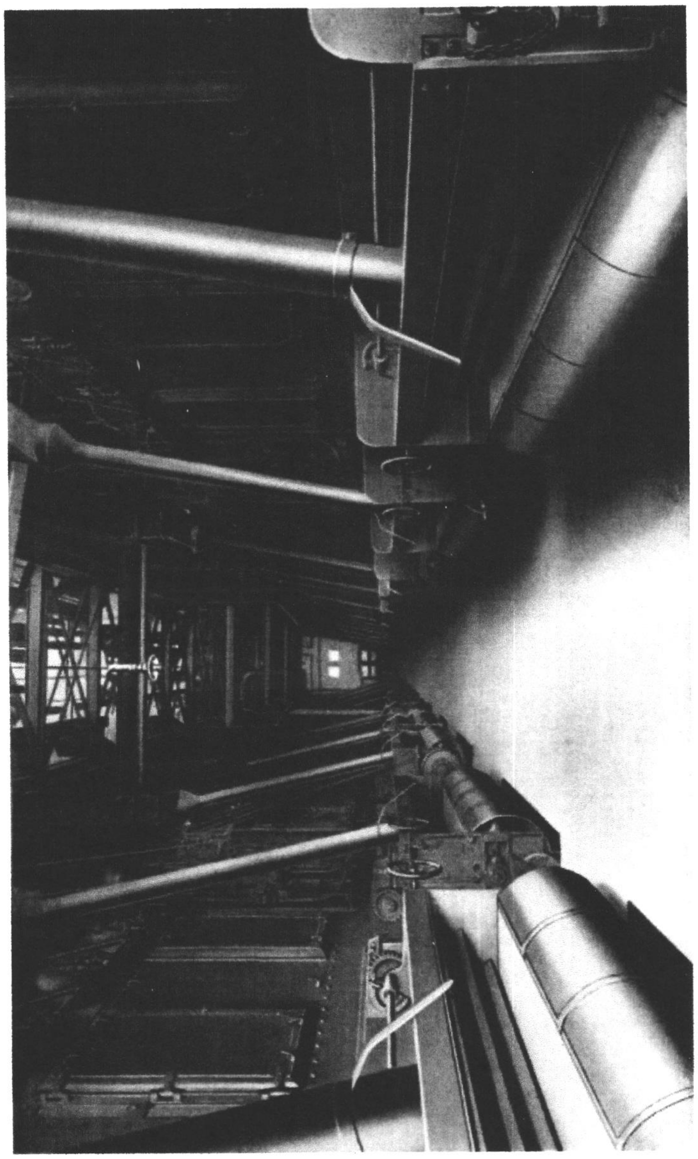
ERJ 12-13-1913

The evolution of the steam-power plant of the Twin City Rapid Transit Company in Minneapolis is a good example of the rapid changes which have been taking place generally in the methods of power production. Originally this plant contained triple-expansion Corliss engines, representing the best practice of twenty years ago, and these were connected through jack-shafts to 150-hp generators, large for the time. This equipment produced electrical energy at high cost for fuel, because the nature of the load did not permit the engine to be used under good operating conditions, and for maintenance, on account of the complicated character of the machinery. Ten years ago a modern steam plant was projected. The firm of Sargent & Lundy designed it to contain ultimately five vertical, cross-compound Allis-Chalmers engines of 5000-hp capacity, direct-connected to three-phase, 13,200-volt, thirty-five cycle generators conservatively rated at 3500-kw capacity, or at, say, 4000 kw on the now standard temperature rise. Three of these engines were installed by 1905, giving the plant an actual capacity of 12,000 kw.

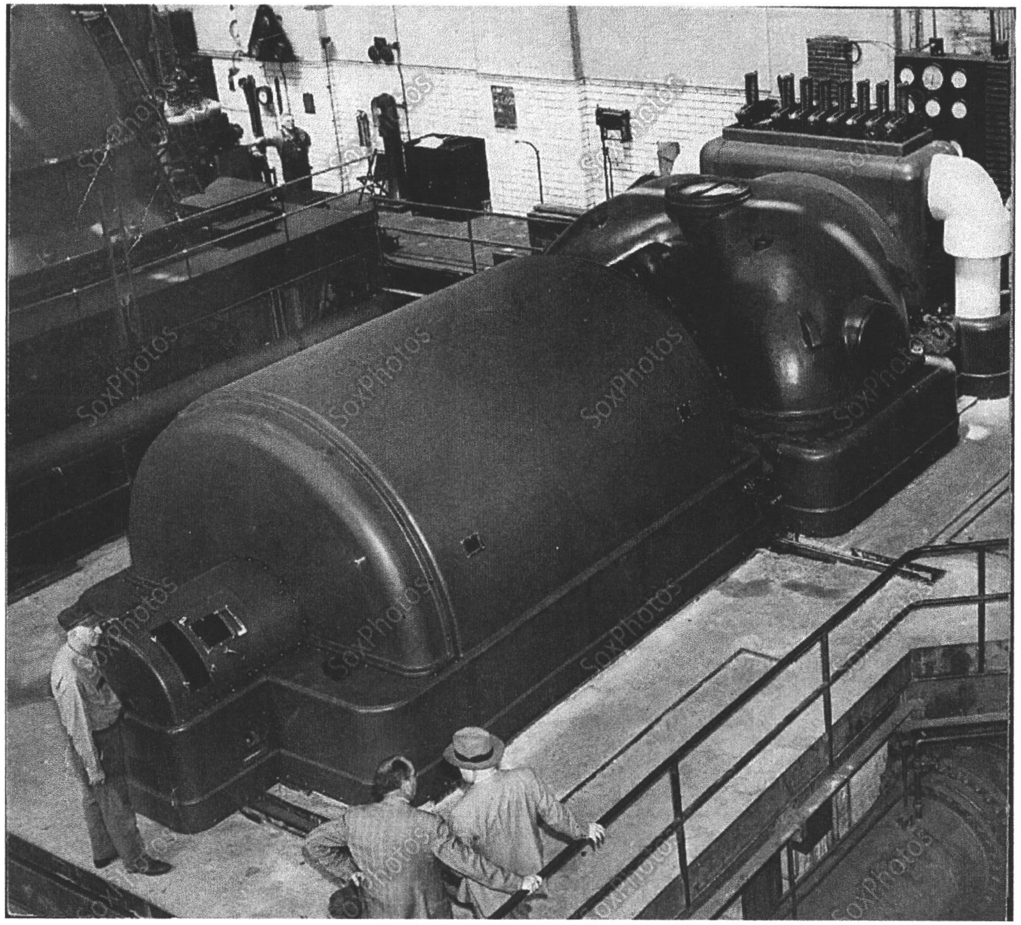
The engines were supplied from a boiler room containing eighteen Babcock & Wilcox boilers with 5560 sq. ft. of heating surface each, giving a nominal rating of 556 hp. These were equipped with Roney stokers of a continuous capacity of 825 boiler-hp to produce a 50 per cent overload output of the boilers. The boilers contained superheaters of a capacity to produce 120 deg. superheat at rated load. Draft was furnished by two Custodis radial-brick stacks, 162 ft. high, mounted on masonry 63 ft. above the boiler-room floor. The flue diameter was 16 ft. Two flues, each of 125 sq. ft. cross-section, connected the boiler up-takes with each stack.

Following the original plan, a fourth engine and eight more boilers were added in April, 1906. By this time, however, the steam turbine had been pronounced a success in Chicago and elsewhere, and instead of the fifth engine two 5000-kw Curtis vertical turbines were installed respectively in February and July, 1907, in the place provided for it. The fact that this space accommodated in turbines three times its capacity for engines is significant. No increase in boiler capacity was made at the time. Complete detailed accounts of the plant as it existed in its earlier years are given in a paper presented by the mechanical and electrical engineer of the company, E. H. Scofield, before the Minnesota branch of the A. I. E. E. in December, 1906, and in one printed in the issue of the STREET RAILWAY JOURNAL for July 27, 1907. The plant was typical of the best practice of the time.

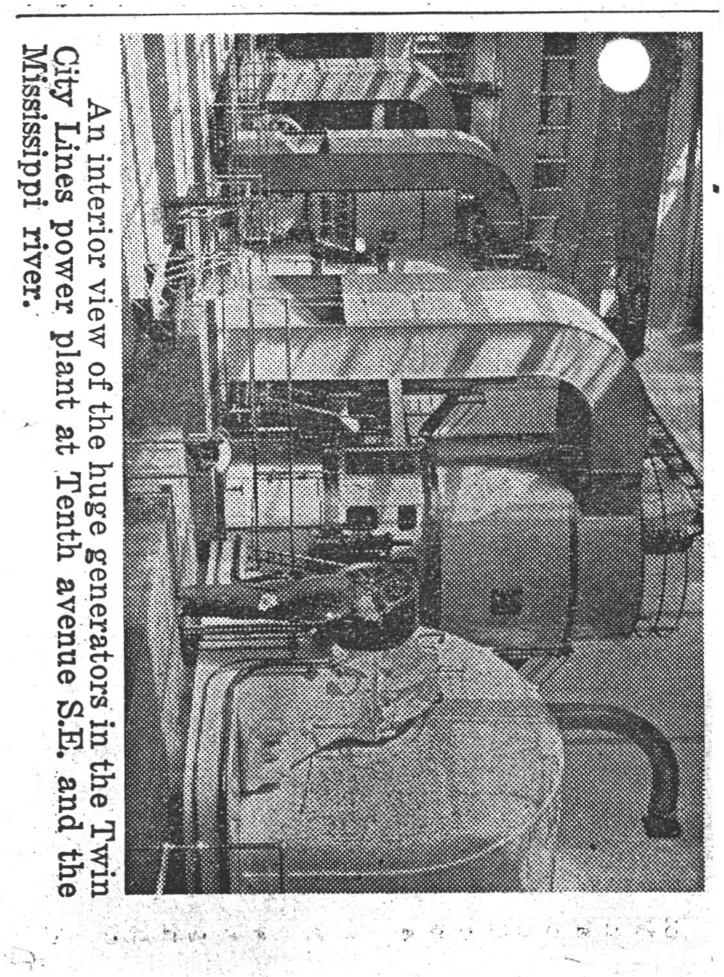
Hardly had the new turbines been installed when it was found possible to secure larger and more economical ones and the process of replacing the engine units began. In the meantime experiments had been made with chain-grate stokers, and in January, 1909, two, in July four more, and during the fall six more, were installed. By this time the stack capacity was greatly overtaxed and one of the brick stacks was replaced, in November, 1910, by two brick-lined steel stacks mounted on structural-steel frames over the boilers. These were 265 ft. high above the boiler room floor, with internal diameters of 14 ft. A 4000-kw vertical Curtis turbine unit was put into service in February, 1911, and in July six more chain grates were installed. Two more boilers, of 5000 sq. ft. heating surface, were added in the space formerly occupied by masonry stack foundations, and the remaining furnaces were equipped with chain grates. Again the stacks were overtaxed, and the second brick one was replaced with two steel ones in August, 1912. During the following month a 15,000-kw turbine set displaced the second engine. More steam being required, two more boilers were added in January, 1913, in the space created by the second brick stack. The installation of a third large turbine, also of 15,000-kw capacity, has just been completed and but one engine of the original four now remains.



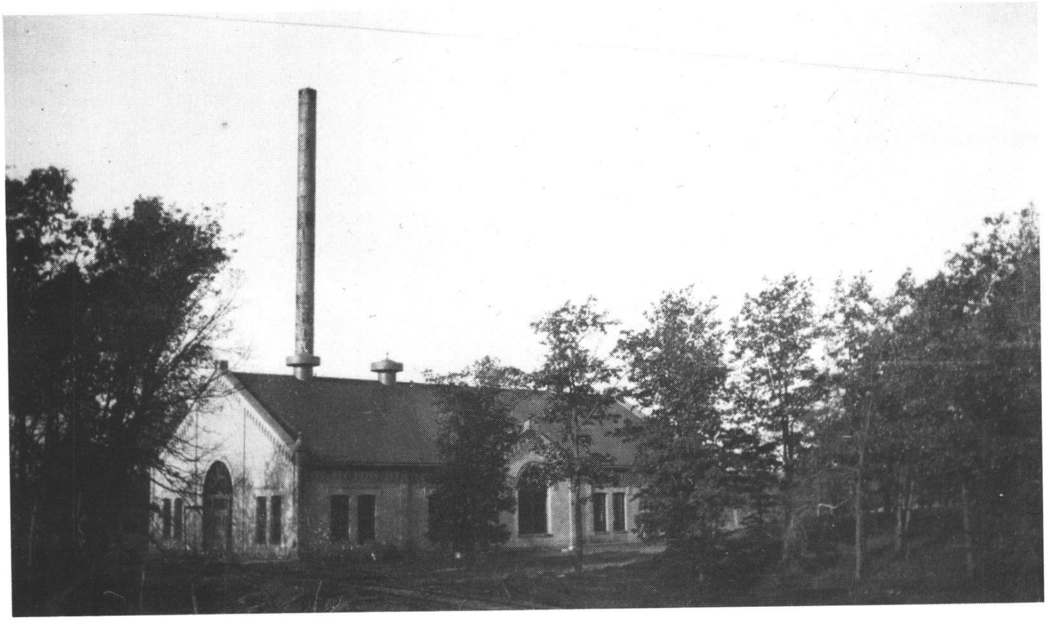
15400 HORSE-POWER INSTALLATION OF BABCOCK & WILCOX BOILERS AND SUPERHEATERS, EQUIPPED WITH BABCOCK & WILCOX CHAIN GRATE STOKERS AT THE PLANT OF THE TWIN CITY RAPID TRANSIT CO., MINNEAPOLIS, MINN.



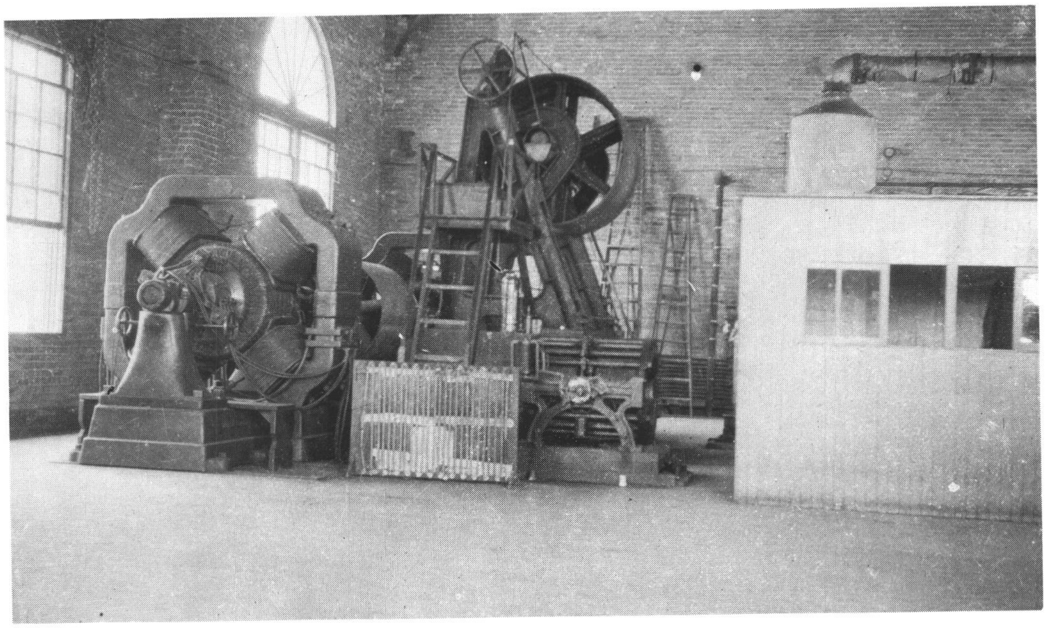
A throw of the master switch Monday (May 27th, 1946) set in operation the new $650,000 steam turbine at the Main Steam Station. It was two years in the building and installing and is designed to replace two smaller turbines and doubles available reserve electric power for the streetcar system.



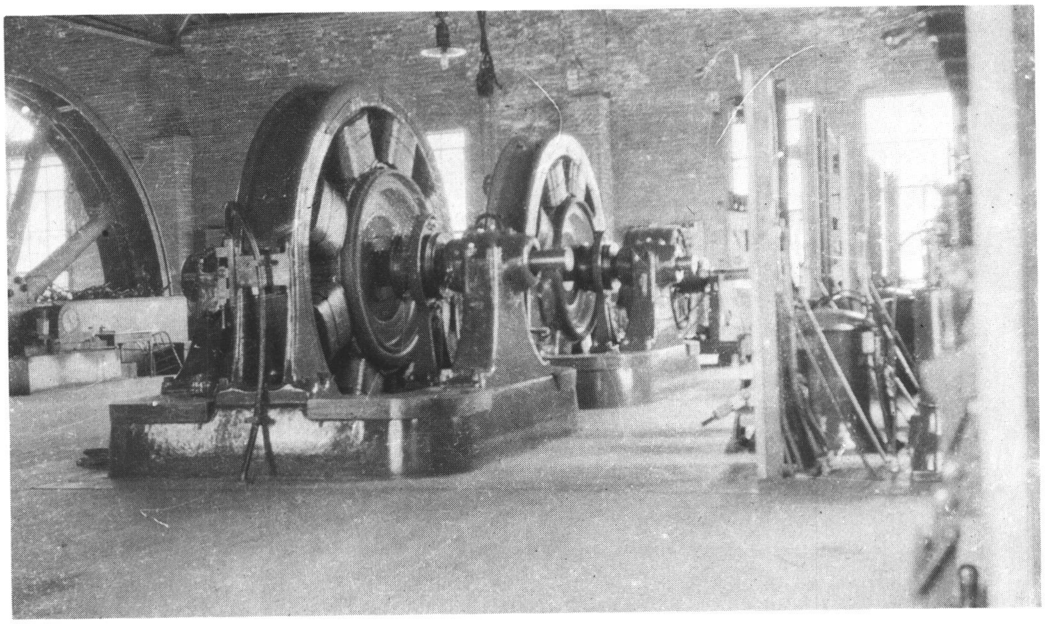
An interior view of the huge generators in the Twin City Lines power plant at Tenth avenue S.E. and the Mississippi river.



The Wildwood Substation as it appeared in 1911. The original steam station equipment was contained in the east (left) half of the building while the substation equipment was later installed in the west half.



The Wildwood steam powerhouse equipment was intact but unused as of 1911, except that the drive belt had been removed. One Corliss engine had been belted to two D. C. generators. The two generators with pulleys for the drive belt are prominent in the photograph. In the center is an electric heater mounted in front of the arc lite machine.



The two rotary converters and control panels in the Wildwood Substation as they appeared in 1911. The flywheel of the Corliss engine can be seen at the far left.

(All photographs historical collection of S. D. Dimond)

~~Facing Page~~

This Page

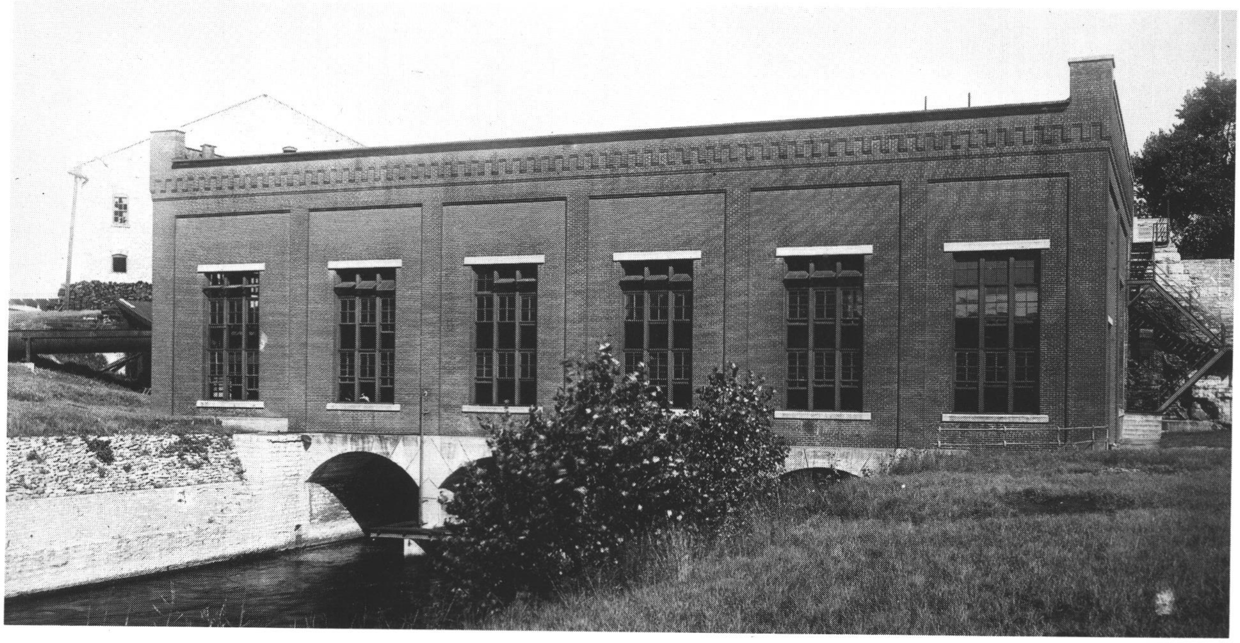
Above: The Hennepin Island Water Power Station, 1926.

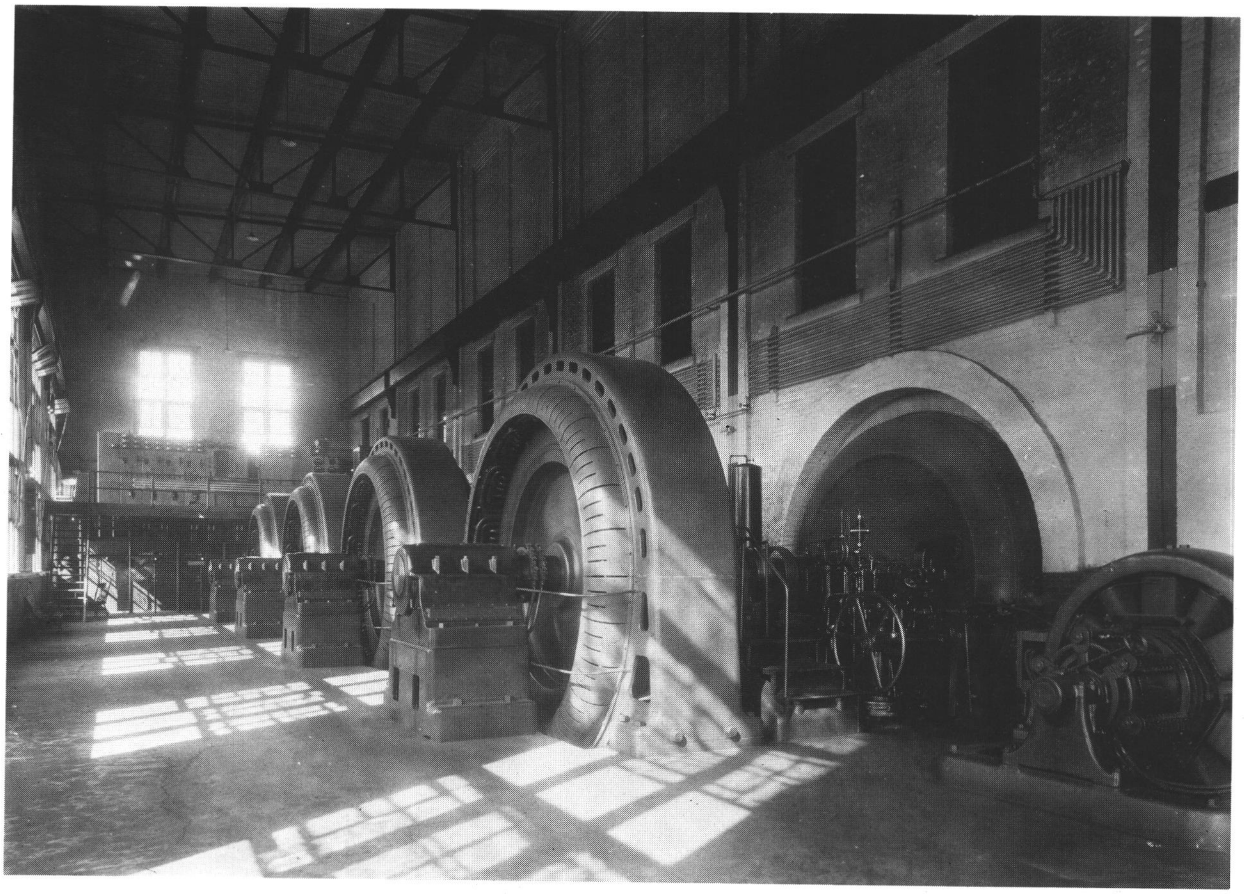
Below: Interior of the Hennepin Island Water Power Station.

(All photographs A. D. Roth; Robert Bowes collection)

Additional Hydro-Electric Power

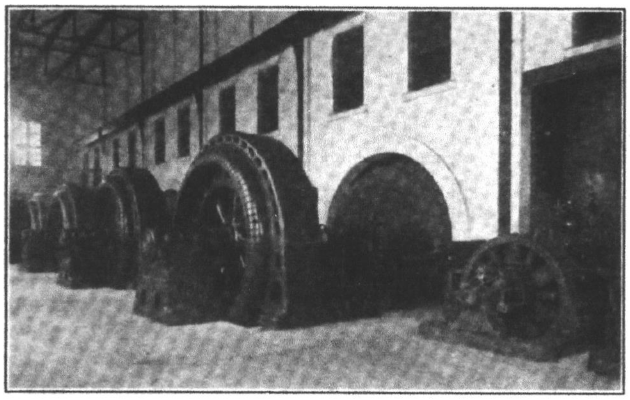
The St. Anthony Falls Water Power Co. began construction in May, 1908, of the Hennepin Island Water Power Station in Minneapolis which was leased to TCRT upon completion. This was equipped with four turbo-electric A.C. generators of 2250 KW capacity each, for a total capacity of 9000 KW.





POWER GENERATING SYSTEM AND RECORDS OF THE TWIN CITY RAPID TRANSIT COMPANY

Several articles have been published within the past year in the ELECTRIC RAILWAY JOURNAL upon improvements made during the past three or four years by the Twin City Rapid Transit Company, particularly in the construction of its Snelling Avenue repair shops, at which all of the repair work on the system is done, and in the erection of extensive car houses at the same point. In the power department changes of almost equal importance have been made. They include additions to the substations, which are now 10 in number, and the completion of arrangements for the receipt of current from a new water-power station at St. Anthony Falls.



Twin City System—Interior View of Hennepin Island Station

Power for the operation of the company's system is now obtained from the original St. Anthony Falls station, the property of the St. Anthony Falls Water Power Company, from the steam-power station of the Twin City Rapid Transit Company and from the new Hennepin Island power station. From the first the company secures power on a 24-hour basis. The greater part of the remaining power is taken from the steam-power plant of the company on the east bank of the Mississippi River just below the Tenth Avenue bridge in Minneapolis. This station operates for about 20 hours a day and has a capacity of about 30,000 hp supplied by four vertical-compound reciprocating engines of 5000 hp each and two Curtis turbines of 5000 kw each. In addition, power is also taken from the Hennepin Island water-power station, which utilizes the overflow from the St. Anthony Falls. This station has been in use only since last summer. Through the courtesy of E. H. Scofield, engineer of power and equipment of the Twin City Rapid Transit Company, and of R. D. Thomas, assistant engineer of the St. Anthony Falls Water Power Company, this paper is enabled to publish an account of the new Hennepin Island power station and the accompanying diagrams, showing the power output of the different stations and other interesting data.

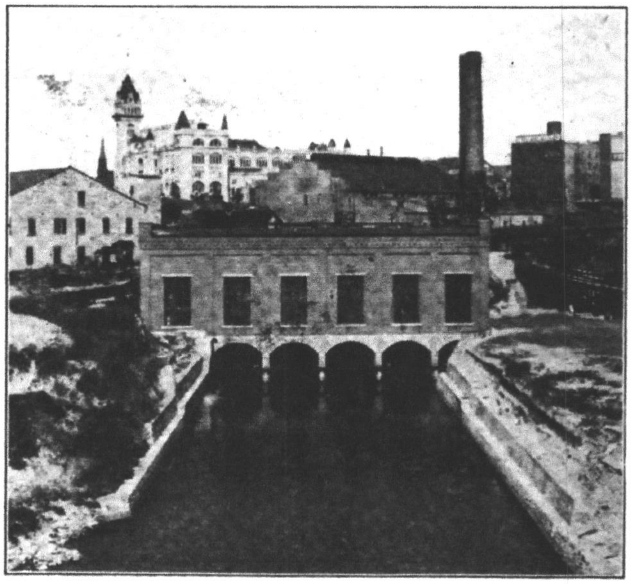
THE HENNEPIN ISLAND POWER STATION

With the recent completion of a new hydro-electric station at the Falls of St. Anthony, Minneapolis, Minn., the St. Anthony Falls Water Power Company has entered a field which is somewhat novel in the exploitation of hydraulic power development.

This plant is located at what is known as the Upper Falls, which have for many years furnished power to the Minneapolis flouring mills and to other minor industries, and is intended to utilize water for power only at such times as the supply may exceed the demands of all earlier lessees. In other words, it is purely a surplus power development, utilizing the flood waters of the river up to the maximum capacity of the hydraulic installation. Furthermore, the plant is ready at all times to use water when the other lessees shut down their wheels, as they do on Sundays and holidays.

In order to sell power of this nature, with its uncertain availability, it was necessary to find a market where its withdrawal at any time would not seriously affect the user, and, at the same time, the price must be low enough to make its use economical even under these conditions. A favorable location provided for a relatively cheap development, and, upon the assurance of a probable market, construction was begun in the spring of 1906.

The wheelpit division walls rest upon a heavy steel reinforced concrete mattress, which also serves as a protection for the soft underlying sandrock. This sandrock forms the foundation of the entire structure from the forebay wall to the wheelpits. When properly protected, it makes a perfectly safe and solid foundation, and in its virgin state is so hard that a pick will make scarcely any impression upon it, but when subjected to the action of the weather or to the erosive effect of water it rapidly disintegrates and washes away. As the tail race was through this sandrock for its entire length, it was deemed advisable to protect it both on the bottom and on the sides. The bottom was paved with limestone blocks, and then covered with a cement grouting. The sides were protected by means of rubble masonry walls laid nearly to the top of the excavation.

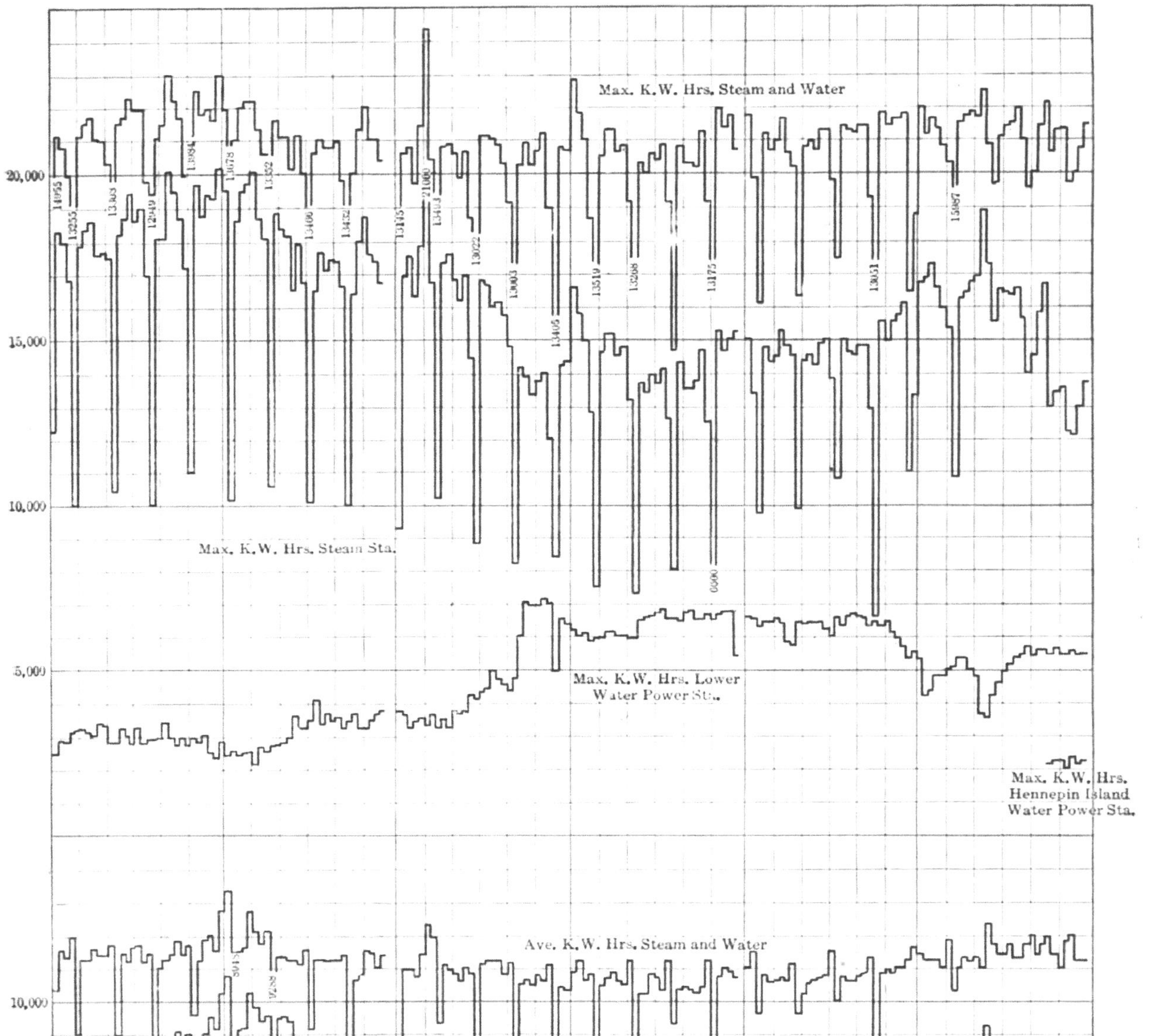


Twin City System—Hennepin Island Power House from Lower End of Tail Race

The generating installation consists of four main units, each of 2250-kw capacity, and two exciter units, each of 150-kw capacity. Each main unit consists of a pair of 48-in. wheels set horizontally in a 3/8-in. steel plate casting, and direct-connected to a 2250-kw, three-phase, 35-cycle generator running at 210 r.p.m. The exciter units are each connected to a 24-in. horizontal McCormick wheel running at 225 r.p.m. The generator room is provided with a 50,000-lb. Pawling & Harnischfeger hand-operated traveling crane.

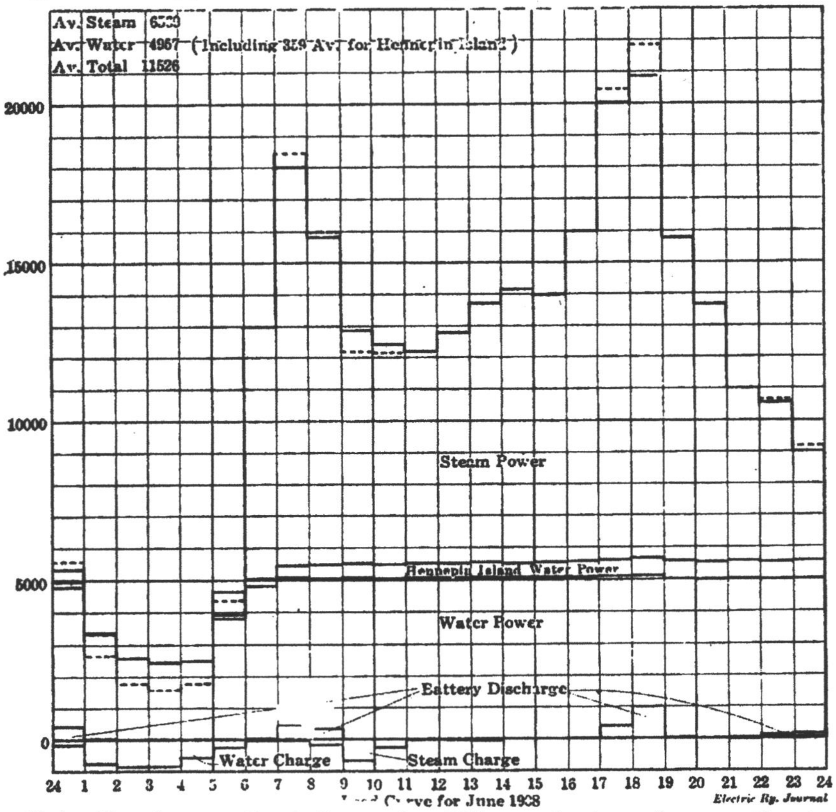
Water is taken from the canal through a trash rack ex-

Digitized by Google



Twin City System—Graphical Record of Output of Different Stations by Weeks, from January to June, 1908

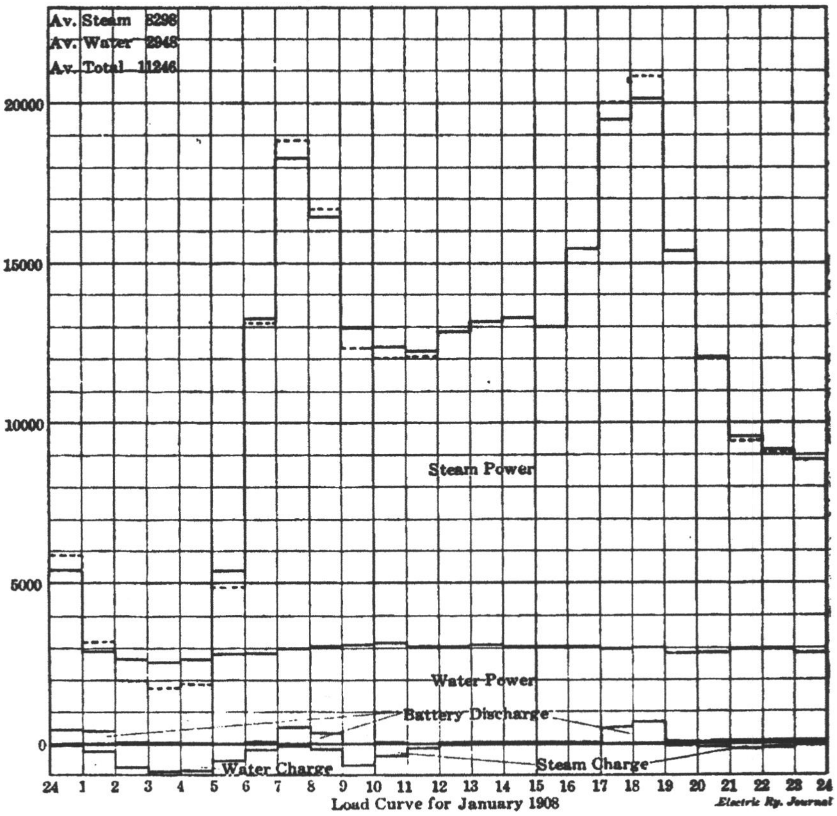
tending the entire length of the power house. This rack is built of 3½-in. x 5/16-in. flat steel bars, securely bolted together with ¾-in. round bolts and spaced with extra heavy 1-in. pipe thimbles. A structural steel frame provides support for the rack and also for a traveling carriage used for operating the penstock gates.



Twin City System—Load Curves for Different Stations, Summer Month

The large penstock gates, of which there is one for each unit, are each 14 ft. wide x 13 ft. 3 in. high, and are built of pine timbers securely bolted together and provided with steel bearing plates. These gates are operated by means of a motor-driven hoist, which is mounted on a carriage traveling over the head gates on two parallel 55-lb. T-rails. The hoisting mechanism consists of a series of gearing belted to a 5-hp motor and drives two ball-bearing bronze nuts engaging two long screws which serve as gate stems. In moving from one gate to another, these screws are disconnected from the gates and travel with the carriage. Each gate is provided with a small hand-operated filler gate which is used for filling the penstocks before raising the gates, thus relieving the hydrostatic pressure on them.

For the exciter penstocks two small hand-operated gates are provided. These gate hoists are of a standard pinion and rack pattern, made by the Dayton Globe Iron Works, of Dayton, Ohio.



Twin City System—Load Curves for Different Stations, Winter Month

The penstocks all pass through a heavy forebay wall and end with a 90-deg. elbow entering the wheel-cases at the top.

The plant is situated on the east shore of the Mississippi River, taking its water from the original mill pond through a canal 350 ft. in length. The water is discharged below the power house into a tail race 280 ft. in length, returning again to the river just above the lower development, known as the Lower Dam.

The canal stands upon a solid limestone ledge, with heavy masonry walls of the same material. It has a clear width of 55 ft. and an average depth of 17 ft. At the upper end there are provided three Stoney type headgates, each gate being 16 ft. 4 in. wide by 18 ft. high. The gate hoist is so arranged as to be operated either by hand or by motor, and the gates may be handled singly or all together. The gates are built with steel frames of 15-in. I-beams decked with 6-in. pine planks, having steel gate-stems which are seated upon roller nests peculiar to the Stoney gate.

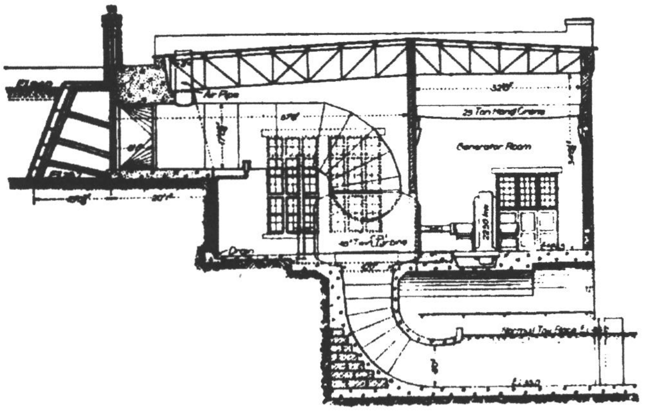
The power house is a brick structure 84 ft. x 136 ft. x 42 ft. high, with a steel skeleton frame supporting the traveling crane and roof trusses. A brick partition wall divides the building longitudinally, with the water wheels and penstocks on the upstream side and generator room and switchboard gallery on the downstream side. A series of heavy concrete arches resting on the wheelpit walls provides suitable support for the machinery and superstructure of the building.

The water wheels are of the "Smith" type, manufactured

Digitized by Google

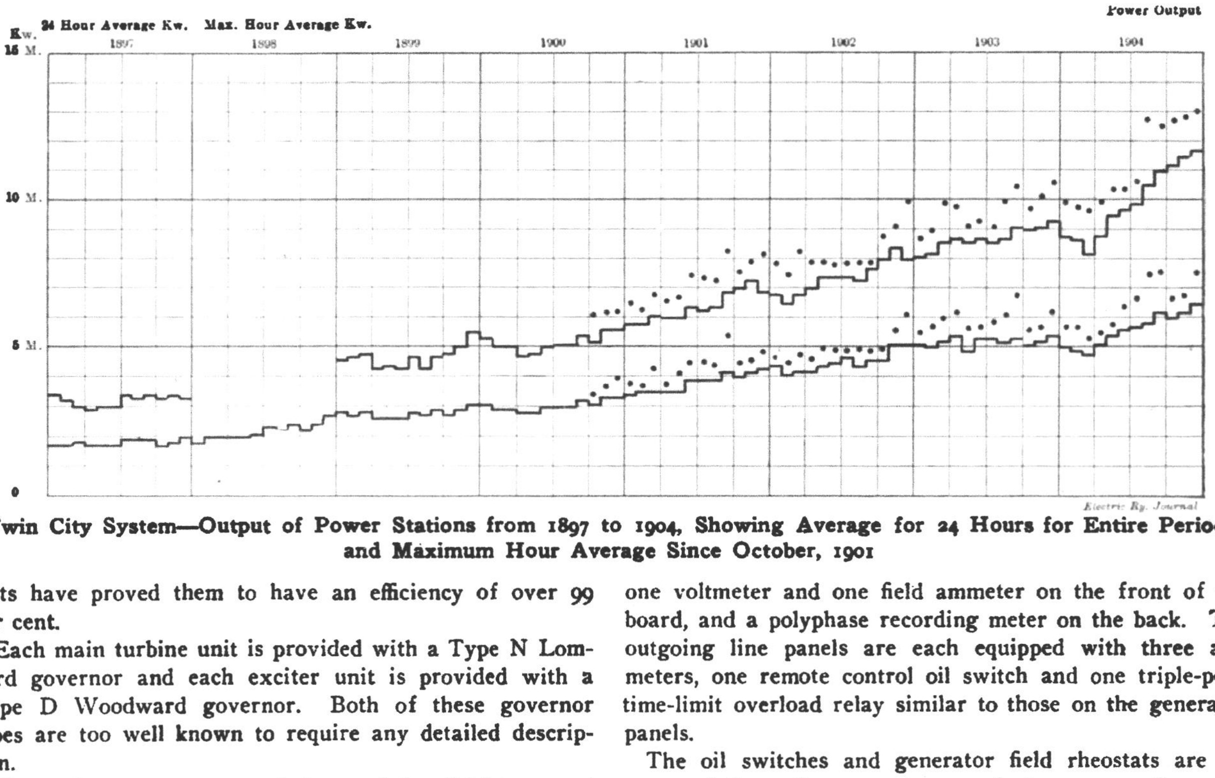
by the S. Morgan Smith Company, of York, Pa. They are set in pairs, horizontally, with center-discharge draft chests. Each unit is provided with a lignum vitæ center bearing suspended from the top of the draft chest by means of heavy steel rods. The entire turbine setting is supported upon steel I-beams securely embedded in the concrete floor.

The draft tubes are of the elbow type, making a right-angle turn at the bottom, thus discharging the water horizontally into the wheelpit. The top diameter at the exit of the draft chest is 10 ft., and from this point to the lower end it gradually enlarges in area and changes in shape until at the mouth it is oblong, being 8 ft. high x 19 ft. wide. The total draft-tube length is about 26 ft., and the normal draft head is about 21 ft.



Twin City System—Cross Section Through Hennepin Island Station

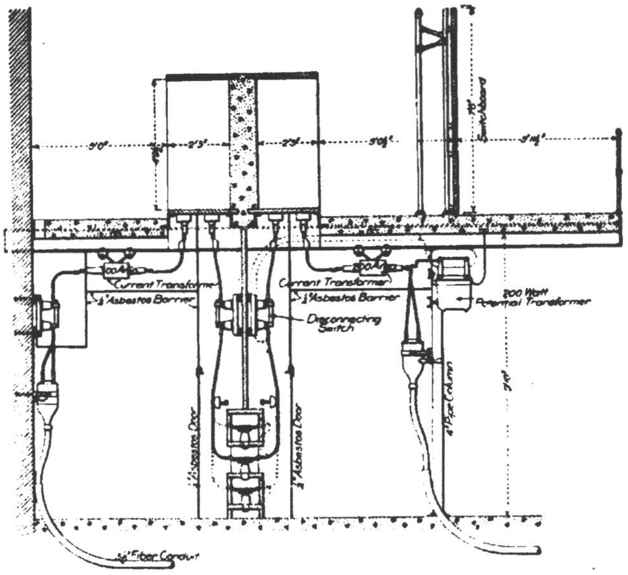
The draft tubes are built of concrete, with a steel-plate lining for about two-thirds of the length. This steel lining was used as a substitute for wooden forms, and also to provide a wearing surface. Although the design of these draft tubes was somewhat novel at the time they were built, tests have proved them to have an efficiency of over 99 per cent.



Twin City System—Output of Power Stations from 1897 to 1904, Showing Average for 24 Hours for Entire Period, and Maximum Hour Average Since October, 1901

Each main turbine unit is provided with a Type N Lombard governor and each exciter unit is provided with a Type D Woodward governor. Both of these governor types are too well known to require any detailed description.

The main generators are of the revolving field type, and are designed to deliver three-phase alternating current at 35 cycles and 13,200 volts when running at 210 r.p.m. Each machine has a rated capacity of 2250 kw at 100 per cent power factor. The generators are separately excited by a 150-kw, 110-volt water-wheel-driven exciter. The exciter installation is in duplicate.



Twin City System—Cross Section Through High-Tension Compartment, Hennepin Island Station

A small motor-driven air compressor is provided for cleaning the electrical machinery.

The switchboard is located on the gallery floor at one end of the generator room, and is made up of 14 panels of blue vermont marble, of which there are four generator panels, four line panels, one exciter panel, one station lighting panel, one storage battery panel and three spare panels for future extensions. Each generator panel is equipped with three ammeters, one power-factor indicator, one voltmeter and one field ammeter on the front of the board, and a polyphase recording meter on the back. The outgoing line panels are each equipped with three ammeters, one remote control oil switch and one triple-pole, time-limit overload relay similar to those on the generator panels.

The oil switches and generator field rheostats are all operated from the generator panels by means of control switches. In addition to the equipment previously men-

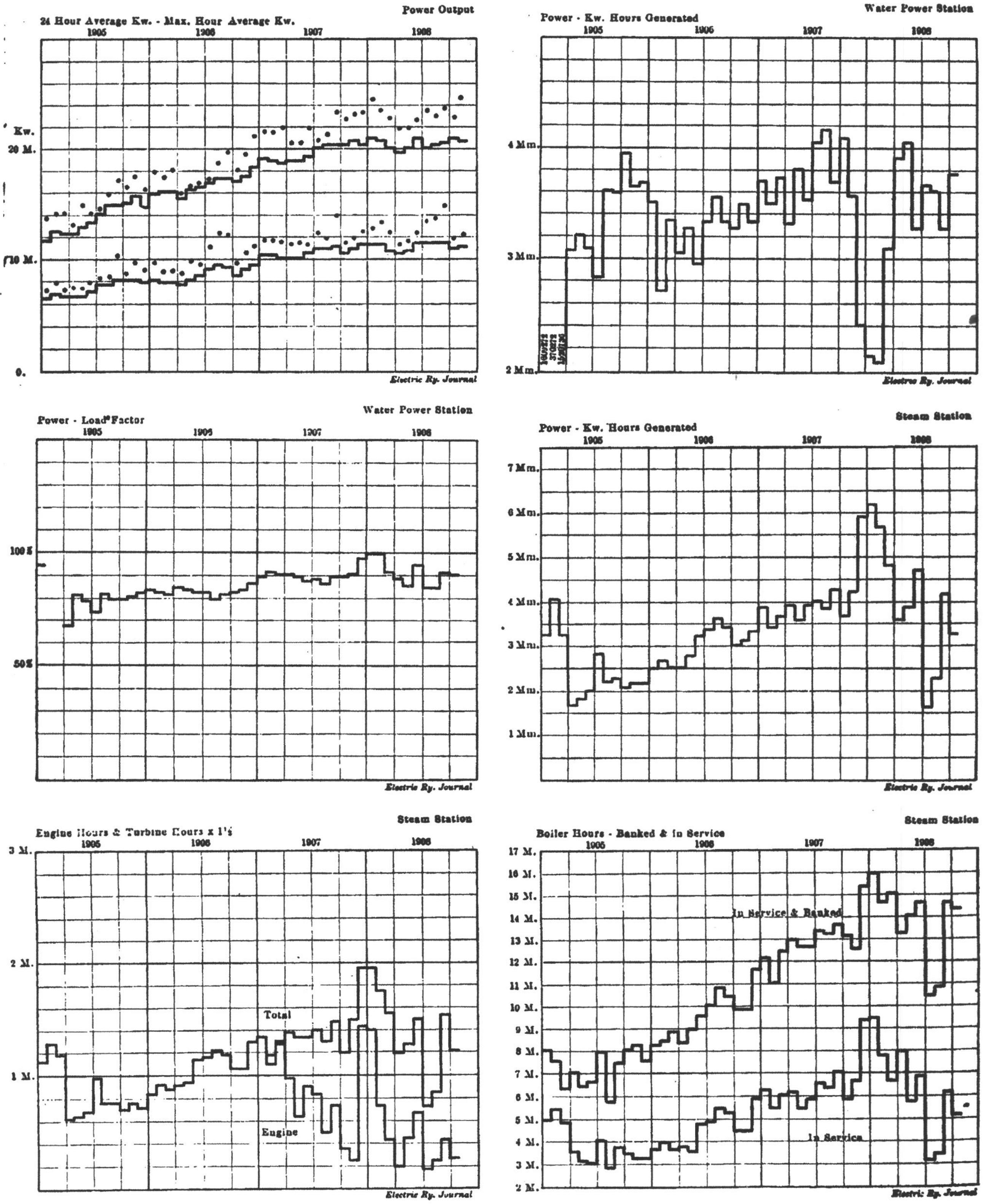
Digitized by Google

tioned, each generator panel is provided with a field switch, potential and synchronizing receptacles and a time relay connected with the automatic high-potential oil switches.

Both exciters are connected to a single panel, upon which is mounted a Tirrill regulator, together with necessary indicating meters and switches.

On the switchboard gallery directly back of the switchboard are placed the high-potential oil switches for both the generator and line panels. These switches are triple-pole, single-throw, 15,000-volt, 300-amp form H3 and are motor-operated.

Directly under the oil switches and resting on the main floor are the busbar compartments. The partition walls of these compartments, and also of the oil-switch cells, are built of concrete in which is embedded expanded metal lath for reinforcement. Asbestos board doors are



Twin City System—Graphical Records of Power Station Statistics

Digitized by Google

provided for the stalls in this structure. There are three buses, each of ¼ in. x 2 in., copper supported longitudinally in position by heavy insulators. The busbar compartments and general arrangements of switches and connection are shown in the cross-section through the switchboard gallery.

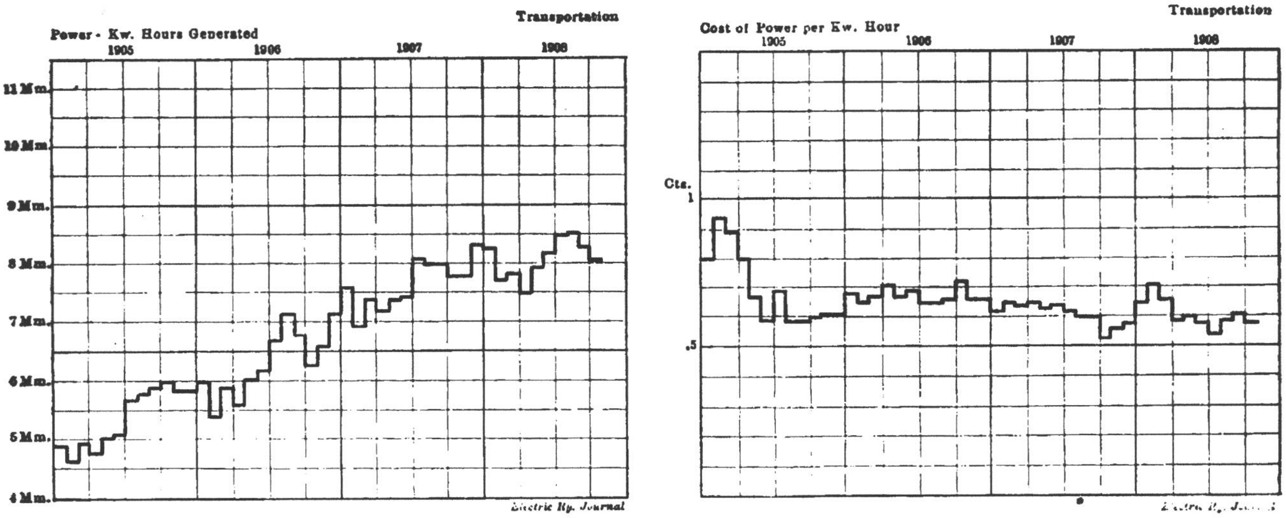
All wires and cables are concealed by the use of metal and fiber conduits wherever possible. The gallery floor is constructed of concrete in which are placed iron-pipe conduits sufficient in number to provide for all necessary wiring for the present plant and possible future extensions. For the generator cables and outgoing line cables 3½-in. bituminized fiber conduits were placed in the main power house floor, the cables being pulled in after the completion of the plant. All cables are lead covered and all other wiring is heavily insulated.

The power generated at this station is sold entirely to the Twin City Rapid Transit Company for the operation of its street railway service in Minneapolis and St. Paul. The station is operated in parallel with another hydro-electric station of 7000-kw capacity located at what is known as the "Lower Dam," about ½ mile below on the river; and also with a steam station of 24,000-kw nominal capacity. The power from these three generating stations is distributed to the various substations in the two cities and there converted into direct current for street railway service.

It is interesting to note the very low cost of this development, which, including all electrical and hydraulic machinery, was about $26 per horse-power. This cost was subdivided as follows:

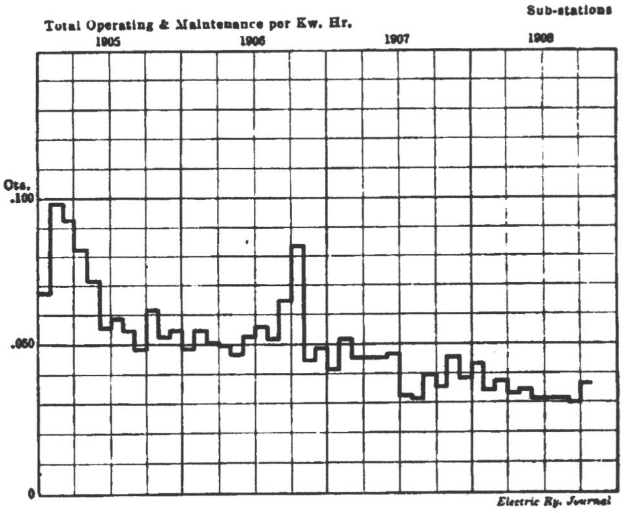
Head race and tail race excavation and construction, complete	$6.00
Power house, complete	6.50
Head gates, cofferdams and miscellaneous structures	1.50
Electrical machinery	8.00
Hydraulic machinery	4.00
Total cost	$26.00

In this connection it should be stated that no dams were built, the water being used from the existing pond already created by the dam of the water-power company. Another factor aiding materially in this low cost was the presence upon the site of all stone required for masonry and concrete work.



Twin City System—Records of Total Kw-Hours Generated and Their Operating Cost

The excavation for the power house necessitated the removal of several thousand yards of a limestone well suited for building purposes. The construction plant was so arranged that, as this stone was removed from the quarry by derricks, it was set upon flat cars and thus hauled directly to the point where it was to be used. The larger stones were used in laying up the masonry canal and forebay walls, whereas the smaller pieces and spalls were all hauled to the crusher and subsequently used in the concrete work.

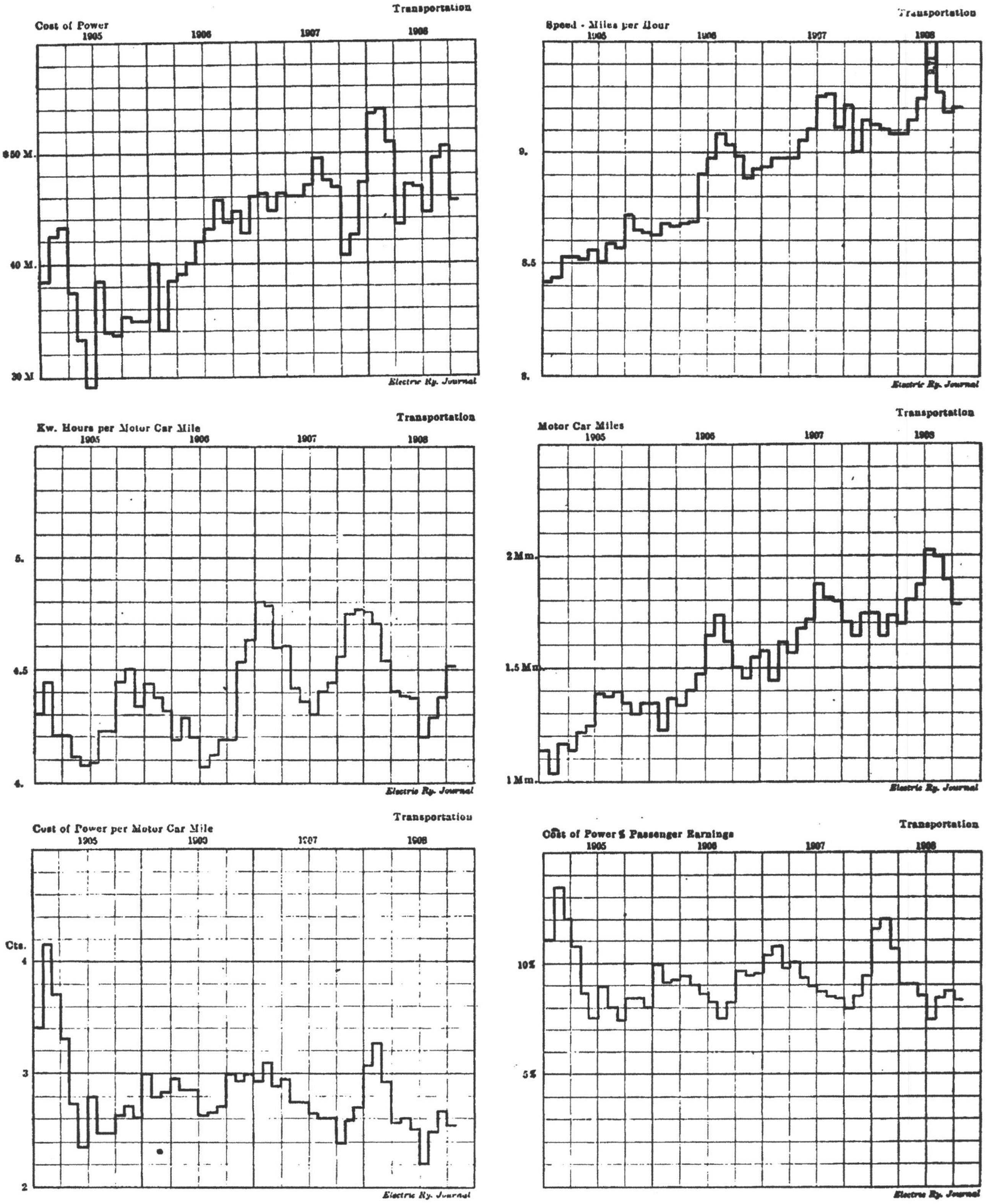


Twin City System—Substation Operating Cost per Kw-Hour

The complete electrical equipment was furnished by the General Electric Company, of Schenectady. The electrical design and installation were made under the direction of E. H. Scofield, M. Am. Inst. E.E., engineer of power and equipment of the Twin City company. The entire plant, exclusive of the electrical equipment, was designed and built by the water power company's forces under the direction of its chief engineer, Wm. de la Barre, M. Am. Soc. C.E. The first unit was completed and put in operation in June, 1908, and the entire plant was running by July 20.

STEAM POWER STATION

The steam-power station of the Twin City Rapid Transit Company was described in the STREET RAILWAY JOURNAL for July 27, 1907. Since that time additions have been made to the power equipment, and the station now contains two 5000-kw Curtis five-stage turbines, as well as



Twin City System—Graphical Records of Transportation Statistics

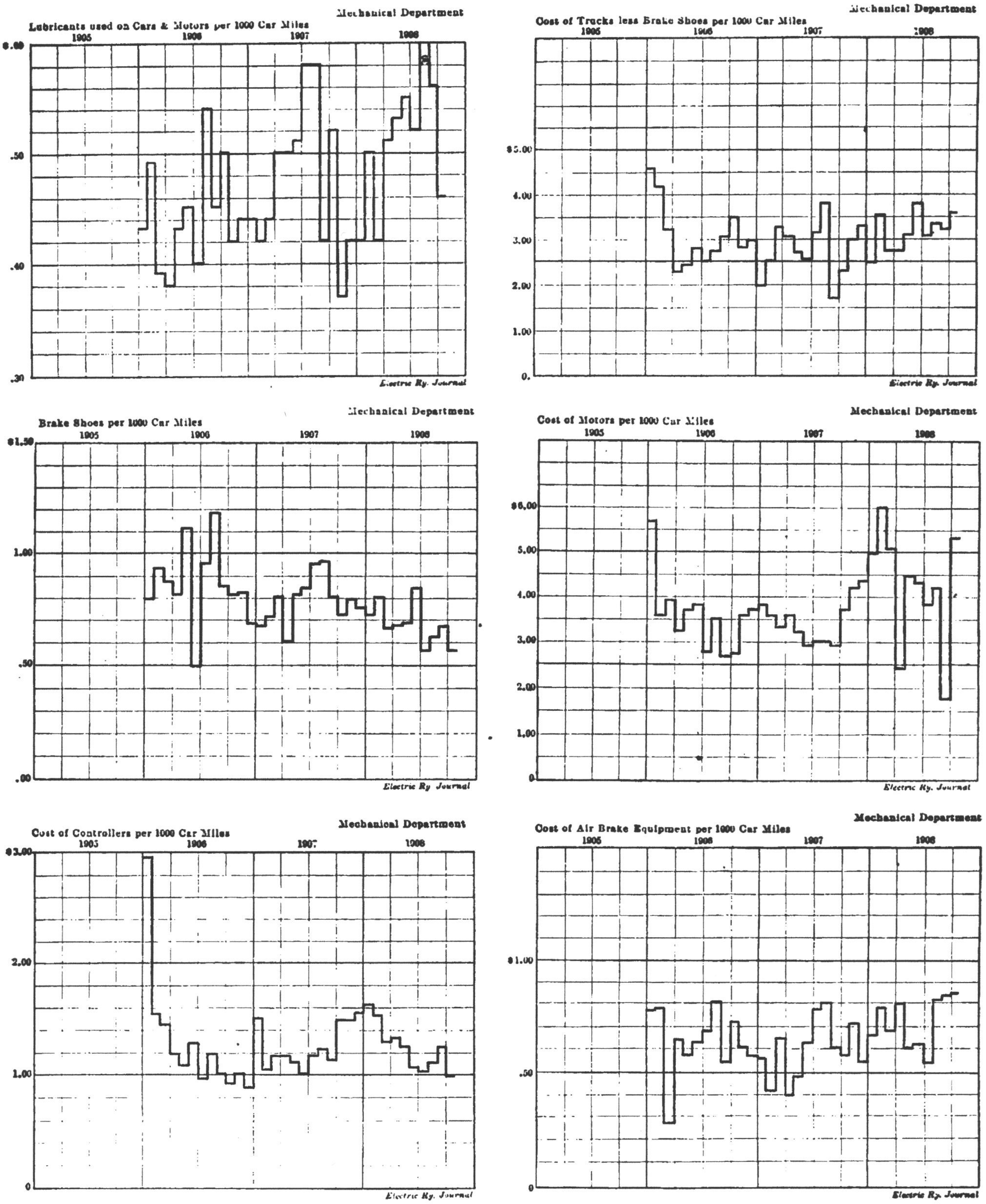
the initial equipment of four vertical cross-compound Allis-Chalmers engines, whose cylinder dimensions are 46 in. and 94 in. x 60 in. The guaranteed steam consumption of the turbines per kw-hour at 175-lb. pressure, 2 in. back pressure, 100 deg. Fahr. superheat is: At half-load, 18.3 lb.; at full load, 17 lb.; at one and a half load, 17.5 lb.; variable between one-half load and one and one-half load, 17.8 lb. The speed variation between no load and full load is guaranteed not to exceed 2 per cent, except in the case of momentary variations, which may be as high as 4 per cent.

The turbines are connected to independent Worthington surface condensers, each with 20,000 sq. ft. of surface and a capacity for condensing 130,000 lb. of steam per hour with condensing water at 70 deg. Fahr.

The step bearings are lubricated by oil supplied at a

Digitized by Google

pressure of 550 lb. per square inch from a Wood accumulator and two Worthington twin pumps with steam cylinder 7½ in. x 6 in. and oil cylinder 2 in. x 6 in. These pumps are connected in relay, so that if one fails to maintain the required pressure the second will start. There is also one electric triplex pump connected to the step-bearing oiling system for emergency use and arranged to start automatically if the accumulator falls below a predetermined height. The discharge from the step bearing and governors flows into closed settling tanks, from which the oil is drawn by the pumps. A bleeder removes water and sediment from the bottom of the tanks to the filter.



Twin City System—Graphical Records of Statistics from Mechanical Department

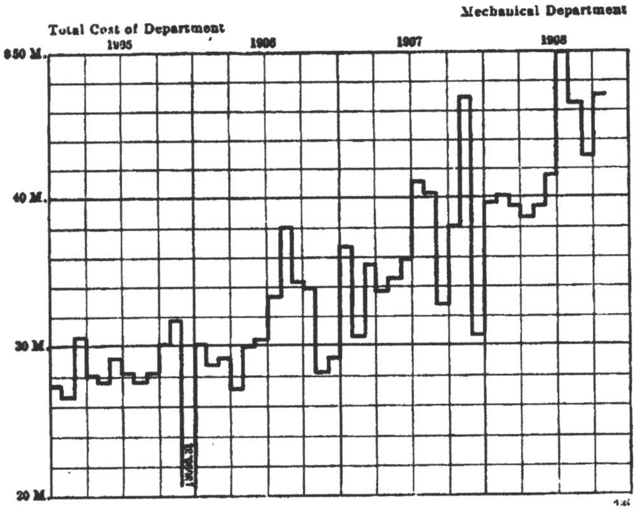
The low-pressure oil supply for general lubrication is under 80-lb. pressure.

GRAPHICAL RECORDS

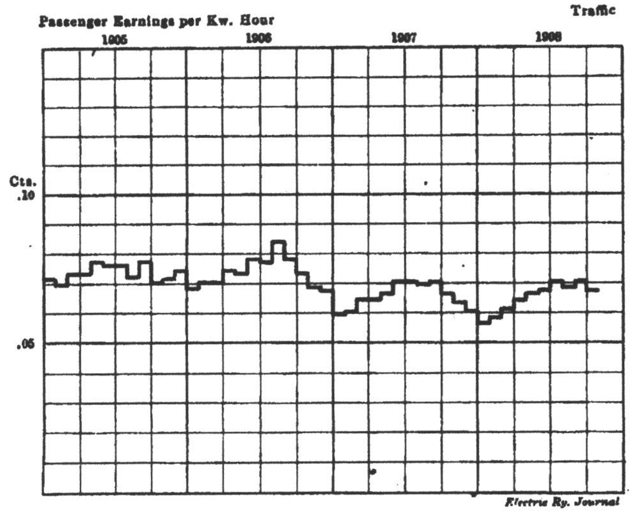
The diagrams on pages 1025 and 1026 show the output of

Digitized by Google

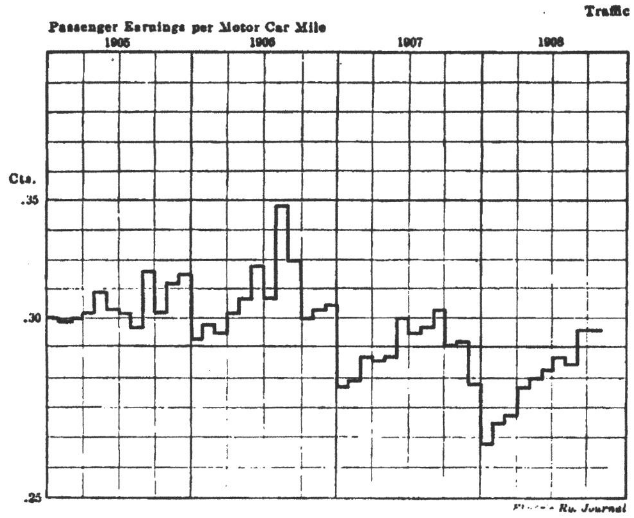
the steam-power station and of the St. Anthony Falls station for railway purposes for the months in 1908 indicated. The other diagrams are part of the graphical records of the Twin City Rapid Transit Company, and are made public through the courtesy of the engineering department and management. In the case of power output they go back as far as 1897, and in the case of maximum demand, are shown on the power chart as black dots, to 1900.



Twin City System—Cost of Mechanical Department



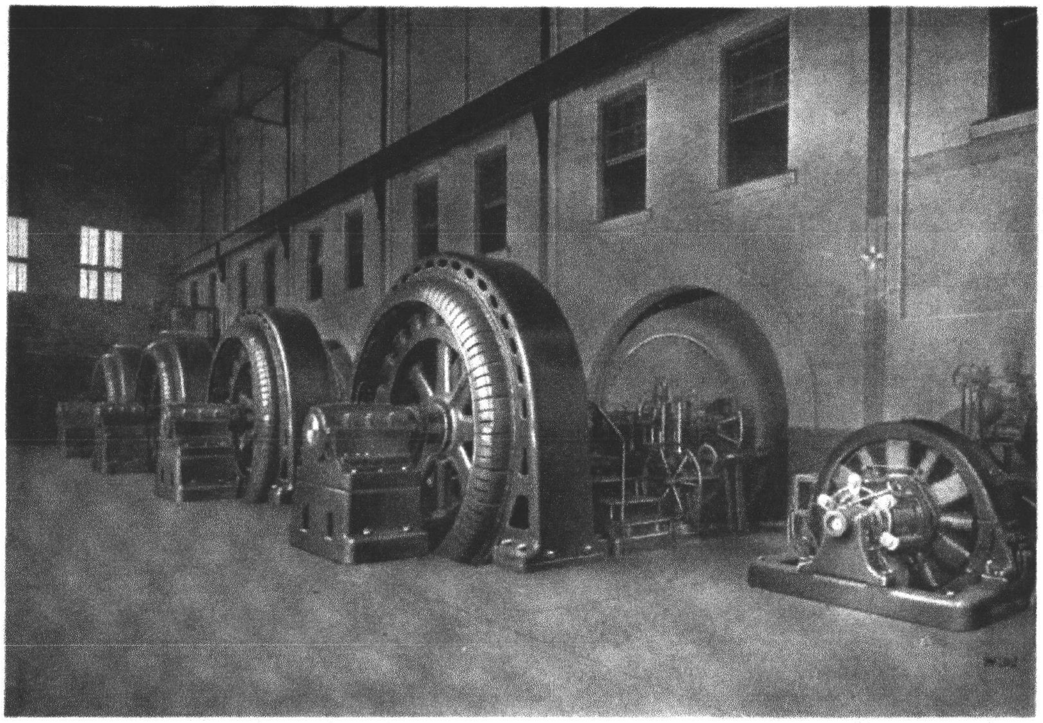
Twin City System—Passenger Earnings Per Kw-Hour



Twin City System—Passenger Earnings Per Motor Car-Mile

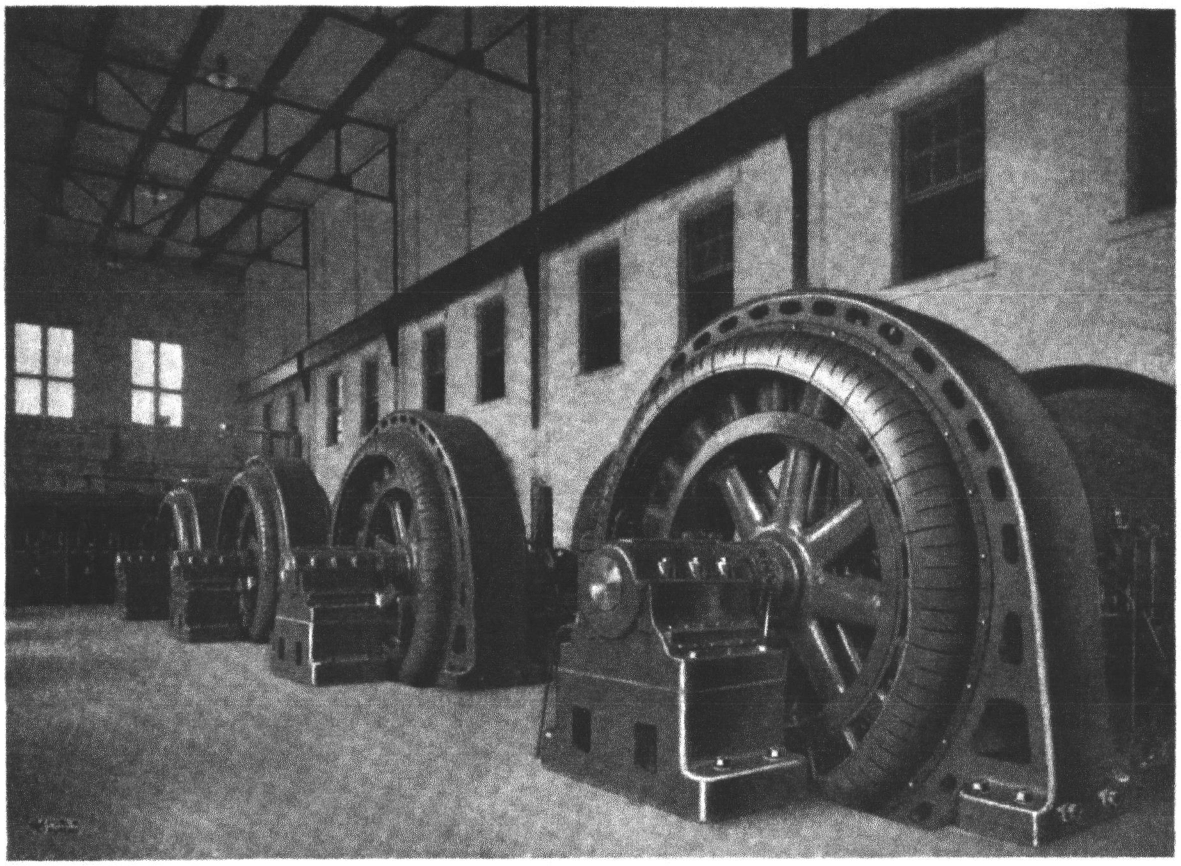
The statistics in other charts are plotted as far back in most cases as 1905. This method is used, in conjunction with the compilation of the actual figures, as a continuous record, the data for each month being added as it becomes available. As the charts carry their own story, no especial comment upon them is necessary, except to point out the evidence of increasing load and traffic and decreased maintenance cost per unit in most of the cases in point.

◆



Hennepin Island Power Station, Twin City Rapid Transit Company, Minneapolis, Minn.
Four 2250 Kw. 13,200 Volt G.E. Waterwheel-Driven Generators

1908



FOUR ATB 2250 KW., 13,200 VOLT, 210 R.P.M. WATERWHEEL-DRIVEN ALTERNATORS
ST. ANTHONY FALLS (MINN.) POWER COMPANY

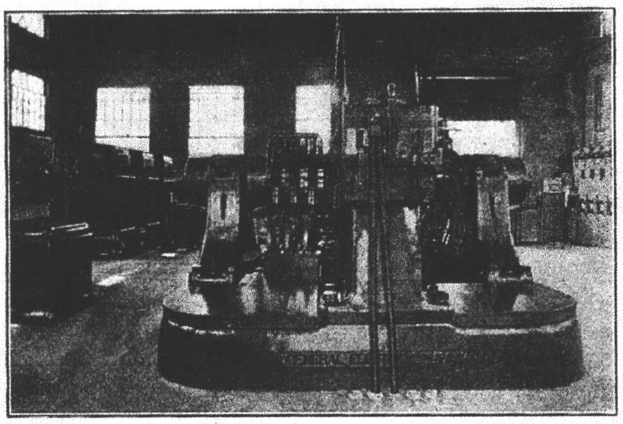
HENN. ISLAND

1908

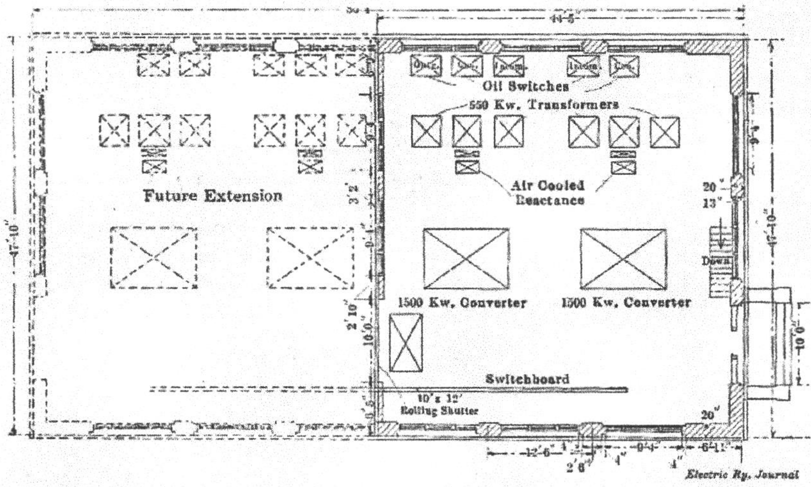
CONCRETE SUBSTATIONS IN MINNEAPOLIS

Illustrations are presented showing constructional details of the Lake Street and the Thirty-second Avenue sub-stations of the Twin City Rapid Transit Company. These stations are both located in Minneapolis and are typical of this company's more recent substation construction. The buildings are alike in general design and contain duplicate converter installations. A comparison of the two structures shows a considerable reduction in floor area in the newer station and a steel-supported roof in place of one of reinforced concrete.

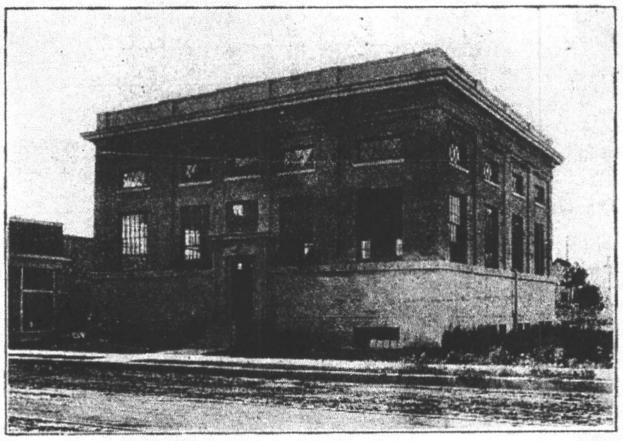
An illustration is presented showing a transverse section of the Lake Street substation. The building has limestone in cement mortar (monolithic concrete) foundations, which support side walls of cement brick. The roof is a concrete slab supported by reinforced concrete girders spanning the entire width of the building. This roof has been found perfectly satisfactory, the only criticism being that the reinforced concrete work could not be executed as fast as the erection of a steel-supported roof. For this reason, when the Thirty-second Avenue substation was designed steel trusses were used to support its roof.


Twin City Rapid Transit—Interior of Lake Street Station

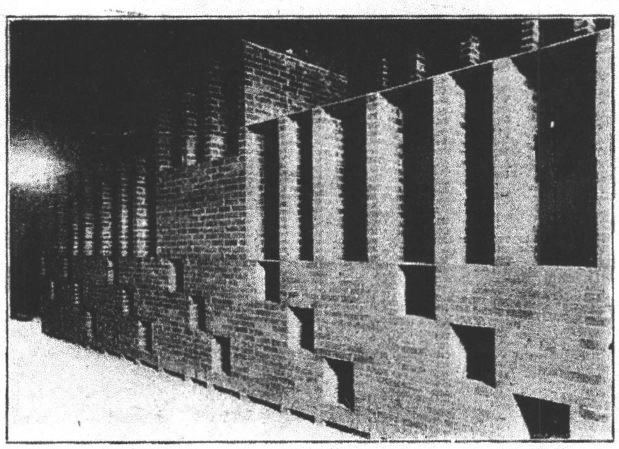
The Lake Street substation contains two 1,500-kw rotary converters, is 50 ft. x 51 ft. in ground dimensions and has a clear height in the machine room of 23 ft. 5 in. In laying out the Thirty-second Avenue substation the blower fans were placed in the basement, thereby effecting a reduction in the size of the structure. The Thirty-second Avenue substation, which is of the latter design, has ground dimensions of 48 ft. 6 in. x 45 ft. 1 in., and a clear height in the machine room of 21 ft. 8 in. This station also is designed for two 1500-kw rotary converters.



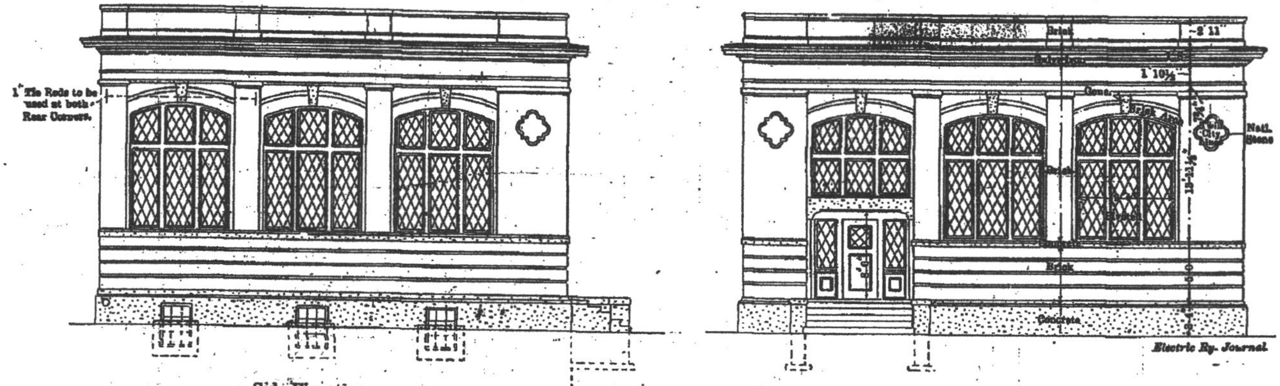
Twin City Rapid Transit—First Floor Plan of 32d Avenue Substation


Twin City Rapid Transit—Lake Street Substation

The equipment in each station comprises, besides two 1,500-kw 6-phase rotary converters, six 550-kw air-blast transformers, five type H-3 remote-control oil switches, two air-blast reactance coils, motor-driven blast fans of 20,000 cu. ft. capacity and a switchboard with the usual machine panels, line panels and direct-current panels for 10 outgoing feeders. Current for conversion in these substations is received at 13,200 volts over duplicate underground lead-covered cables. The electrical equipment in these substations was supplied by the General Electric Company.


Twin City Rapid Transit—Bus Compartment in Basement

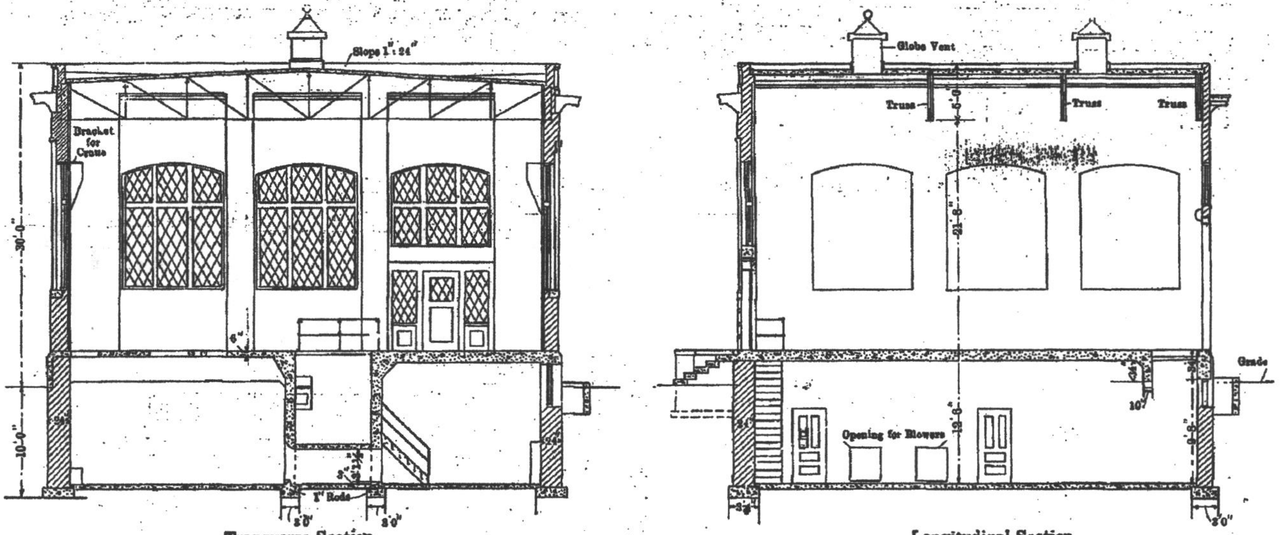
A wiring diagram is presented showing the main and auxiliary circuit for the Lake Street substation. It will be noted that this arrangement of wiring is adapted for an extension of the apparatus and building to double its present size and capacity. Illustrations are presented showing the general arrangement of machinery in the Lake Street substation and the general appearance and constructional details of the bus-bar compartments. These compartments, as illustrated, are built up of cement brick and asbestos board. Special


1" Tie Rods to be used at both Rear Corners.
Brick
Concrete
Nat. Stone
Electric Ry. Journal

Side Elevation

Front Elevation

Twin City Rapid Transit—Elevations of Thirty-second Avenue Substation

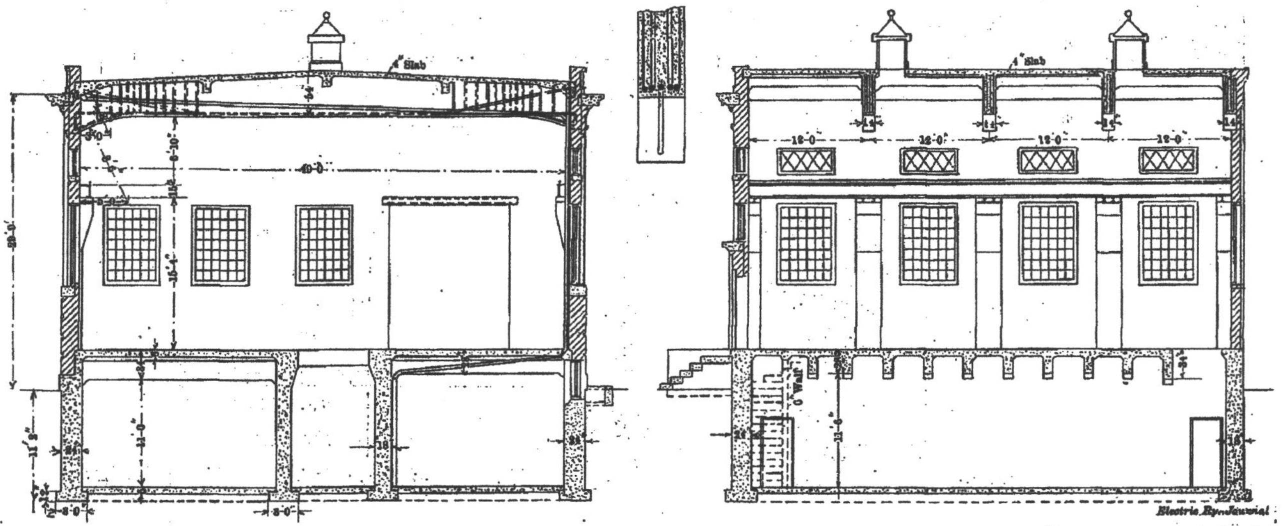

Slope 1":24"
Bracket for Crane
Globe Vent
Truss
Opening for Blowers
Grade
1" Rods

Transverse Section

Longitudinal Section

Electric Ry. Journal

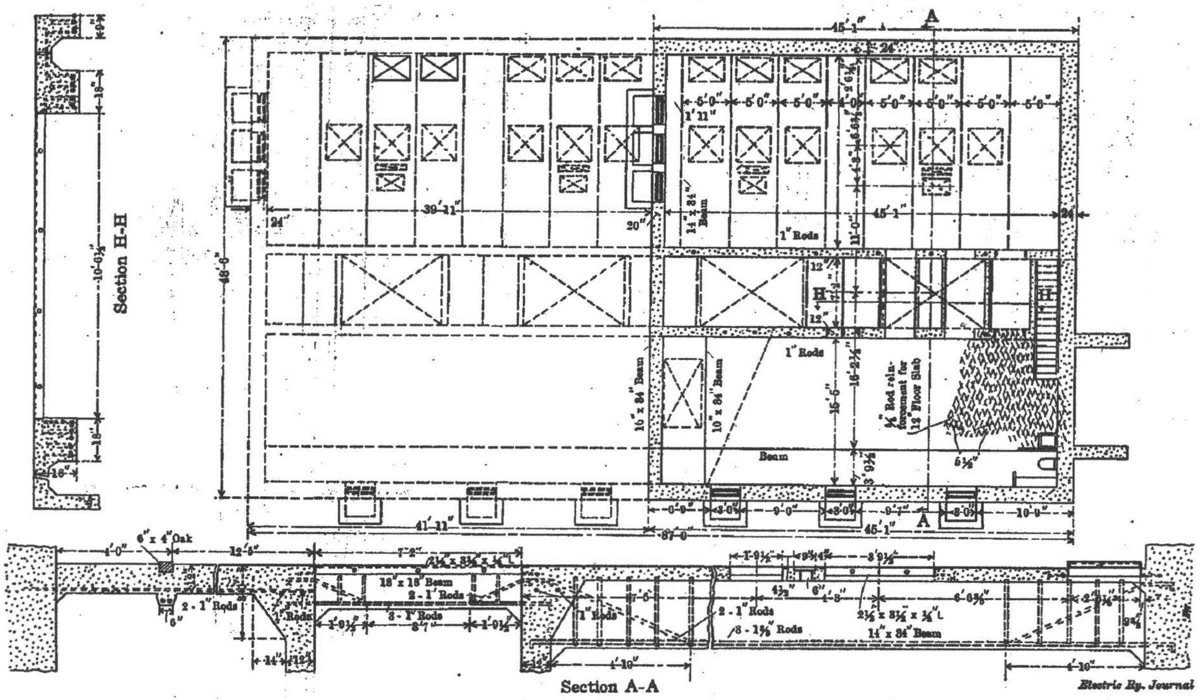
Twin City Rapid Transit—Sections of Thirty-second Avenue Substation


4" Slab
Electric Ry. Journal

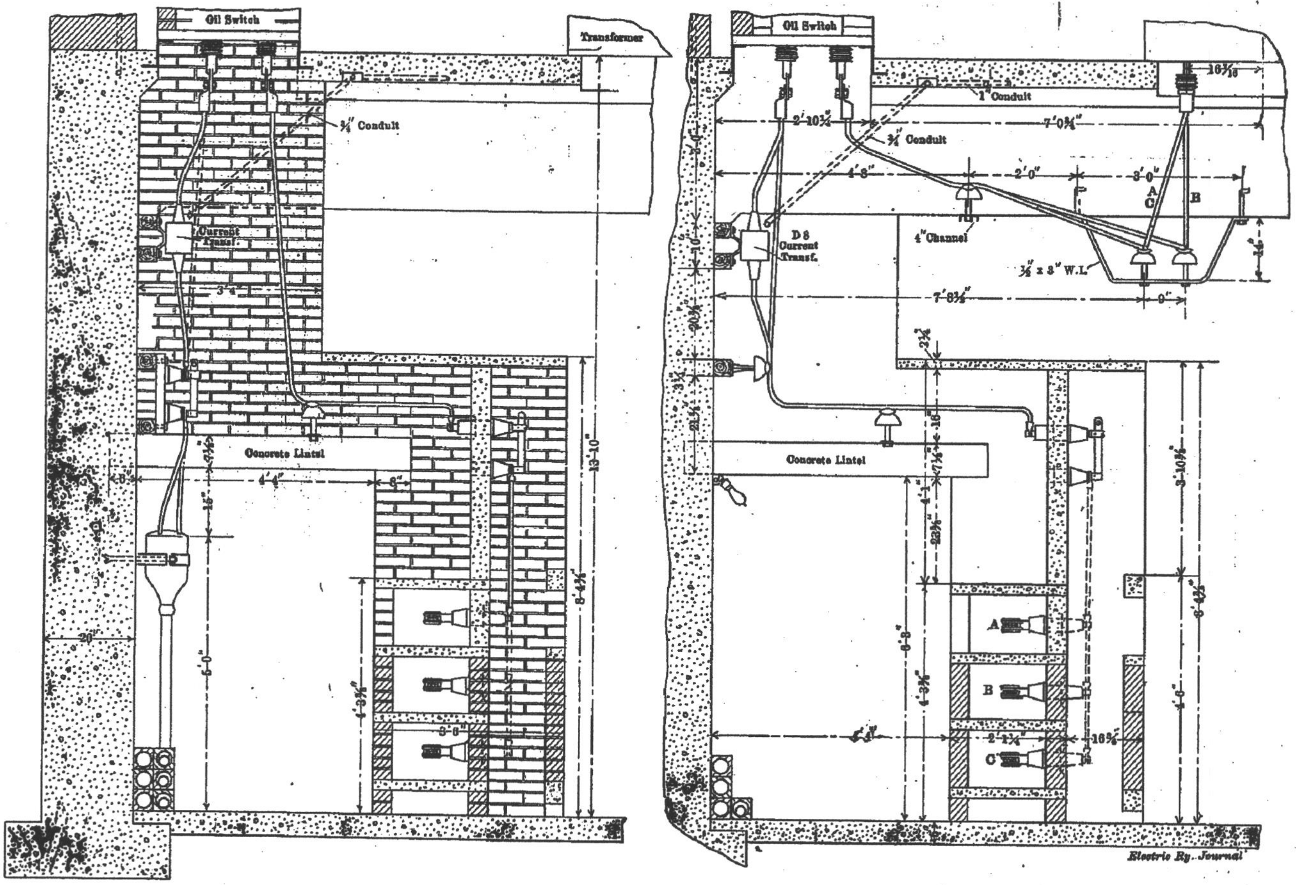
Transverse Section

Longitudinal Section

Twin City Rapid Transit—Sections of Lake Street Substation

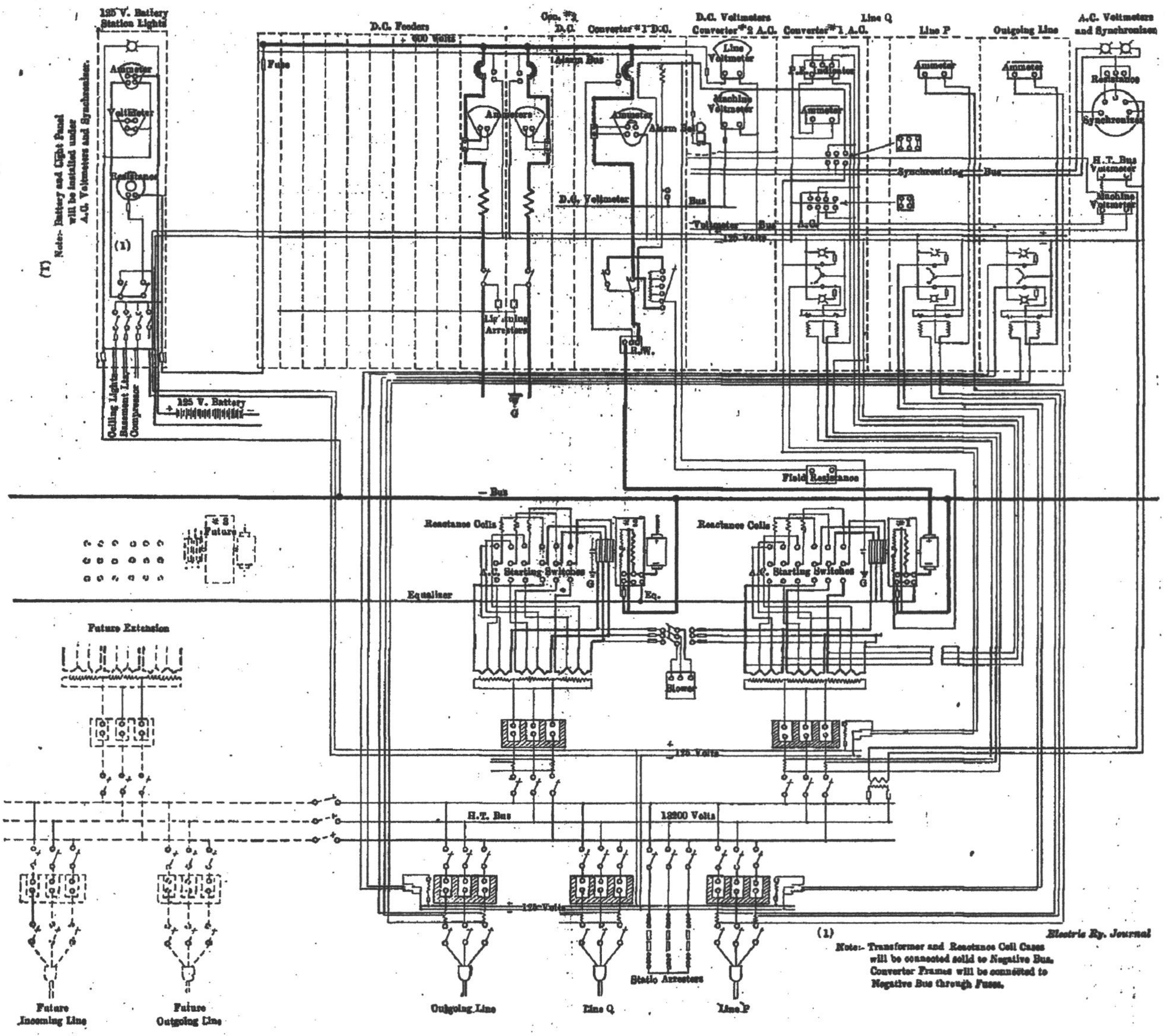

Section H-H
A
H
Section A-A
1" Rods
Beam
14" x 34" Beam
10" x 34" Beam
18" x 18" Beam
2 - 1" Rods
3 - 1" Rods
8 - 1⅝" Rods
6" x 4" Oak
¾" Rod reinforcement for 12" Floor Slab
Electric Ry. Journal

Twin City Rapid Transit—Basement Plan of Thirty-second Avenue Substation


Oil Switch
Transformer
¾" Conduit
Current Transf.
Concrete Lintel
Oil Switch
1" Conduit
¾" Conduit
D S Current Transf.
4" Channel
⅜" x 3" W.I.
A
B
C
Concrete Lintel
Electric Ry. Journal

Twin City Rapid Transit—Sections Showing Incoming and Outgoing Lines and Connections from High Tension Bus to Transformers of Lake Street Substation effort has been made to keep the high-tension arrangements as simple as possible and thus provide against any accidental interruption of service. The vertical sections through the busbar compartments illustrate the simplicity of the high-tension connections between the switches, transformers, buses and incoming cables. Only one high-tension bus is provided at each substation, but this bus may be fed by either of two incoming cables, so that the factor of safety against interruption is large.

The substations are lighted by 80 incandescent lamps arranged in clusters beneath silvered reflectors supported close against the roof.


125 V. Battery
Station Lights
Ammeter
Voltmeter
Resistance
(1)
Note:- Battery and Light Panel will be installed under A.C. Voltmeters and Synchronizer.
(1)
Ceiling Lights
Basement Lights
Compressor
125 V. Battery
D.C. Feeders
+ 600 Volts
Fuse
Ammeters
Lightning Arresters
G
Con. #2 D.C.
Converter #1 D.C.
Alarm Bus
Ammeter
Alarm Bell
D.C. Voltmeter
R.W.
D.C. Voltmeters
Converter #2 A.C.
Line Voltmeter
Machine Voltmeter
Bus
Voltmeter Bus
125 Volts
Converter #1 A.C.
P.F. Indicator
Ammeter
A.C.
Line Q
Line P
Ammeter
Synchronizing Bus
Outgoing Line
Ammeter
A.C. Voltmeters and Synchronizer
Resistance
Synchronizer
H.T. Bus Voltmeter
Machine Voltmeter
Field Resistance
— Bus
#3 Future
Reactance Coils
A.C. Starting Switches
#2
G
Eq.
Equalizer
Reactance Coils
A.C. Starting Switches
#1
G
Blower
Future Extension
125 Volts
H.T. Bus
13200 Volts
125 Volts
Static Arresters
(1)
Note:- Transformer and Reactance Cell Cases will be connected solid to Negative Bus. Converter Frames will be connected to Negative Bus through Fuses.
Future Incoming Line
Future Outgoing Line
Outgoing Line
Line Q
Line P

Electric Ry. Journal

Twin City Rapid Transit—Wiring Diagram of Lake Street Substation

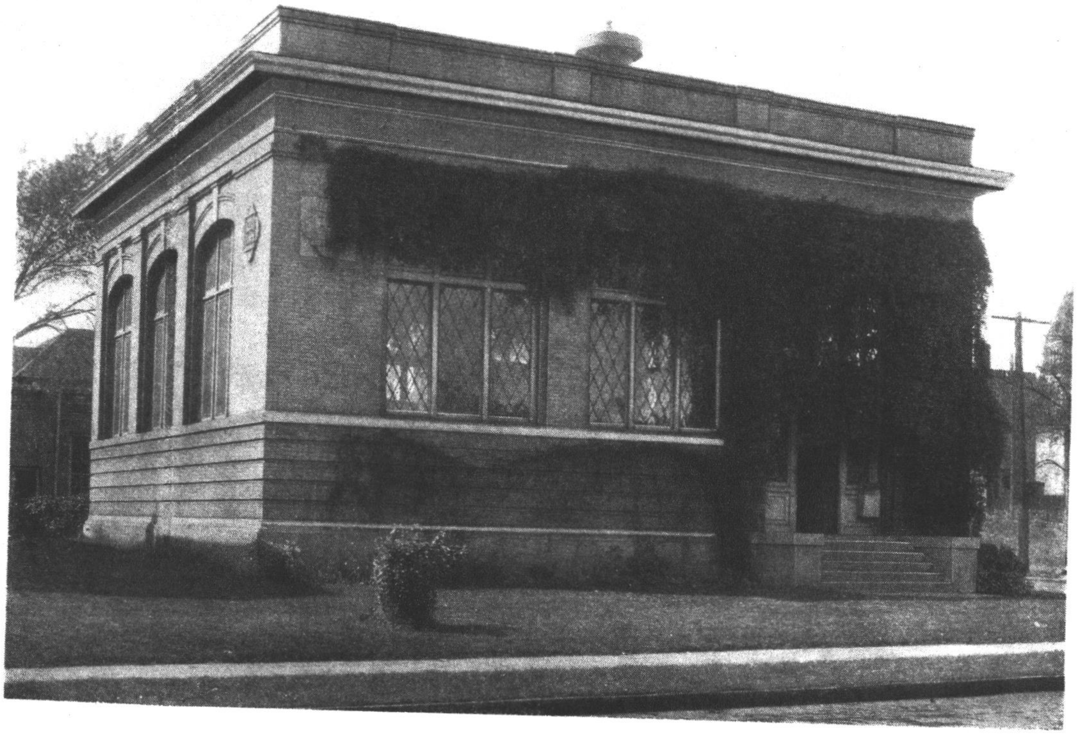
One of the telephone companies in Minneapolis has installed a rather interesting switch equipment in the Lake Street substation of the Twin City Rapid Transit Company. This switch equipment serves to tie the lead sheaths of the telephone cables to the negative return cables at the substation. To effect this connection the telephone company has installed a 500,000-circ. mil cable between its cables and this substation. The length of this cable is about 4000 ft. This connecting cable is joined to the common ground which connects the sheaths of all lead-covered telephone cables. At the substation the connecting cable terminates in a remote-control quick-break switch which serves to connect the telephone company's cable with the railway company's track-return cable. This connecting switch is placed in the basement of the substation, and in the machine room, directly above, the telephone company has erected a small board on which are the control buttons for the switch just described, and an ammeter and voltmeter.

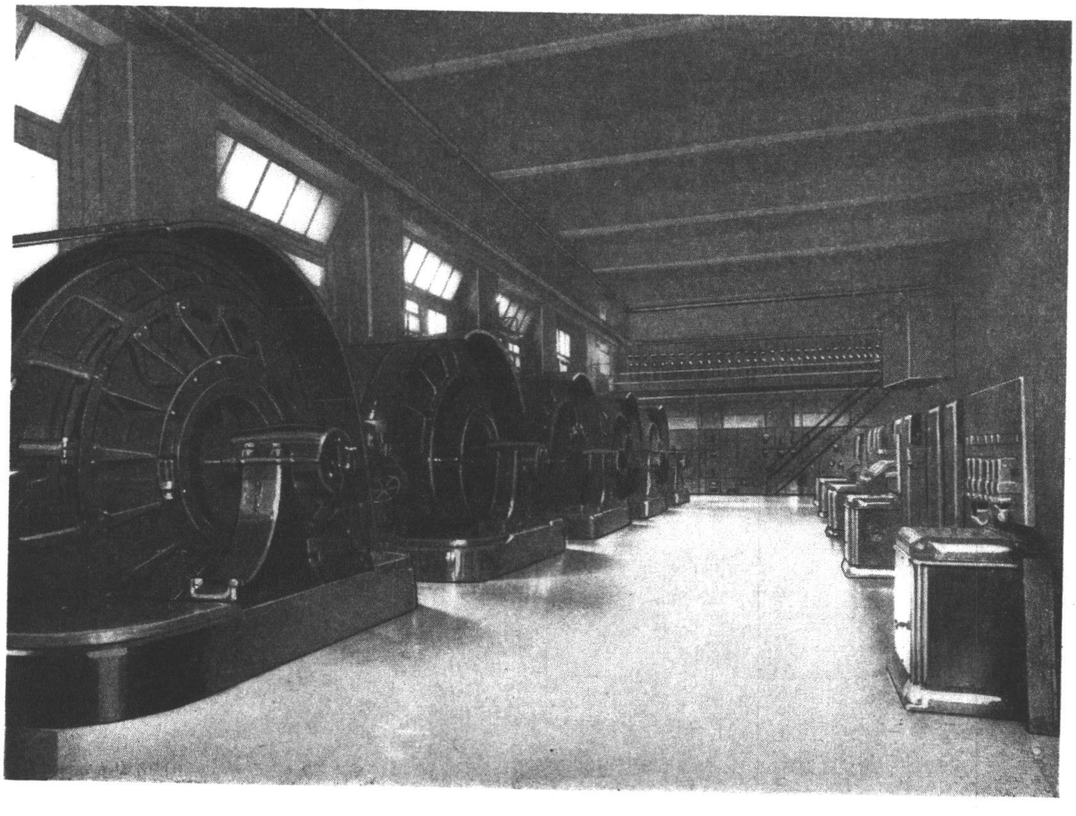
It is the practice to close the connecting switch only when the rotary converters in this substation are running and open the switch when the rotaries are shut down. Thus the telephone company's cables are not grounded through this station when no current is being fed from it. This positive connection between the negative of the railway company's system and the lead sheaths of the telephone companies' cables is said very largely to prevent any electrolysis that might be occasioned by railway current.

◆

The Auckland (New Zealand) Harbor Board calls for tenders for 16 electric cranes, to be submitted by Oct. 1 to W. & A. McArthur, Ltd., 18 Silk Street, London, E. C., England, from whom specifications and diagrams may be procured. Further particulars may be obtained from the Bureau of Manufactures, Washington, D. C.

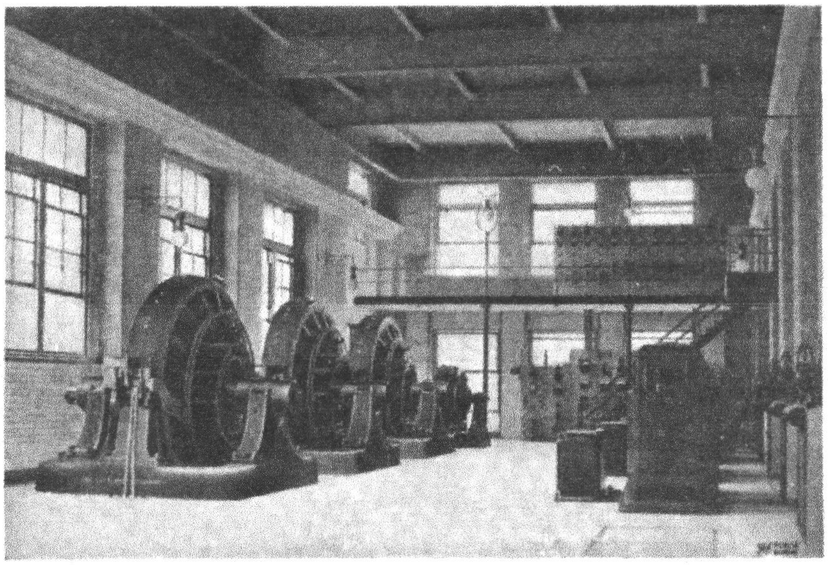
UNIVERSITY SUBSTATION, MINNEAPOLIS





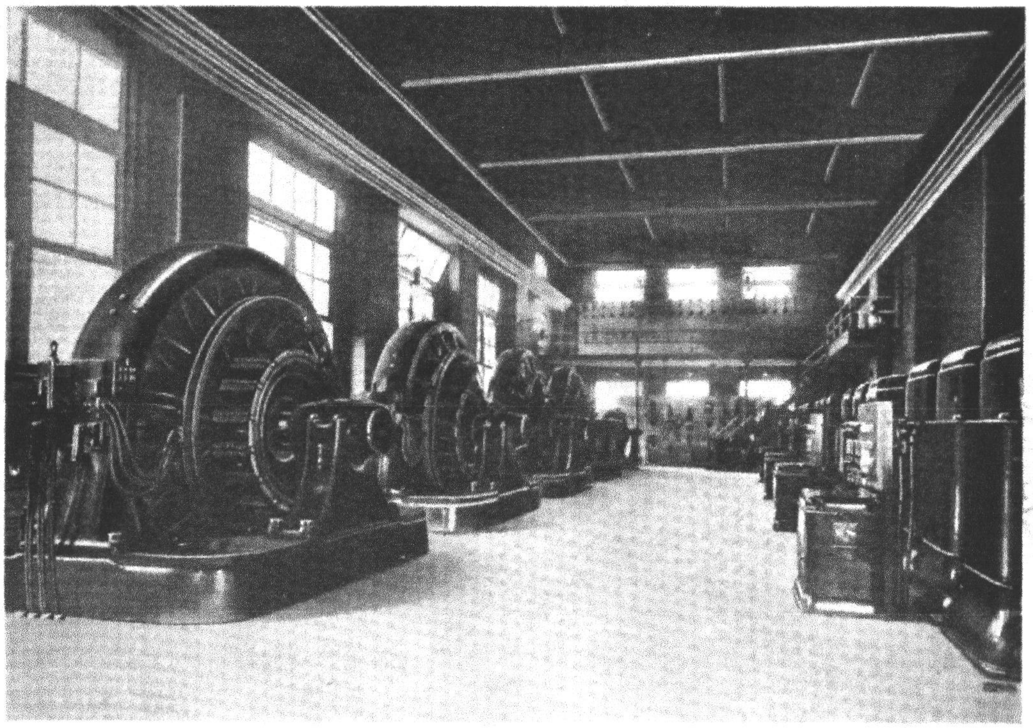
MINNEAPOLIS—
General Office
Building and Sub-
Station Power House,
Interior View

11th St. Substation

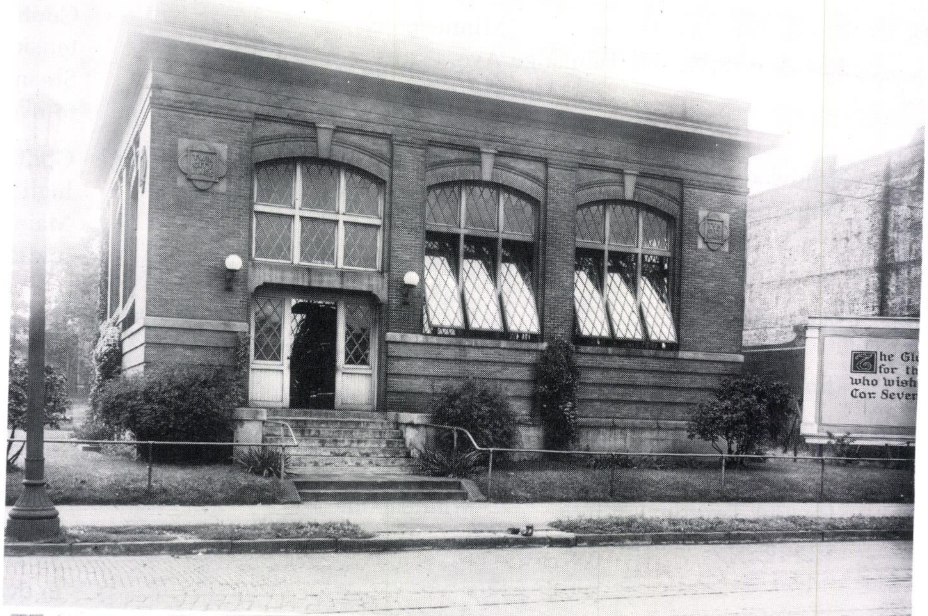


11TH ST.

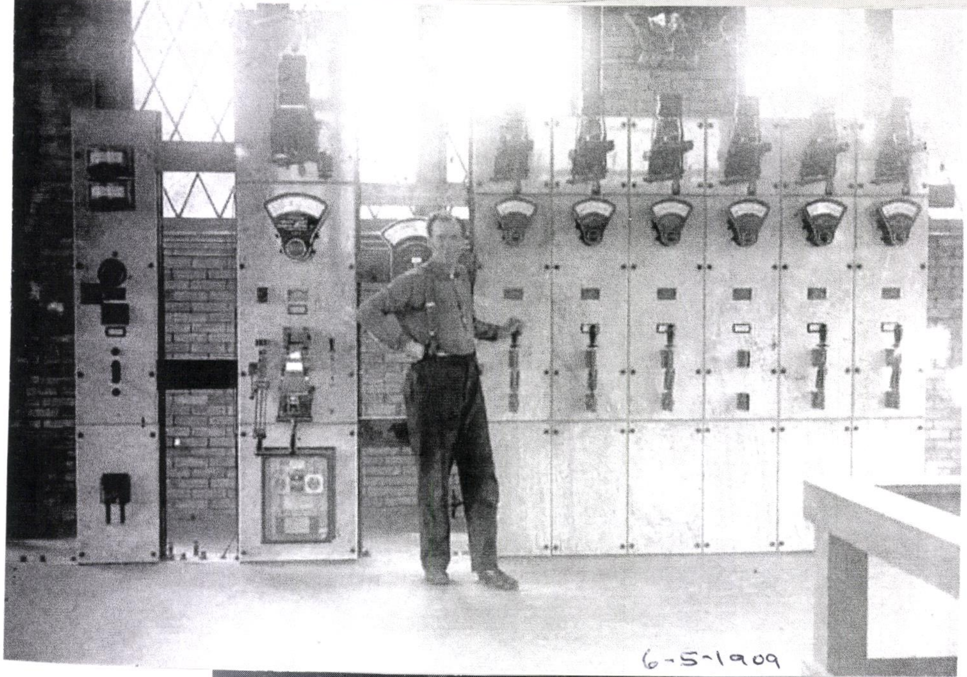
Substation of Twin City Rapid Transit Company, Minneapolis
1500 Kw. Converters with Single-phase Air Blast Transformers 13,200 volts



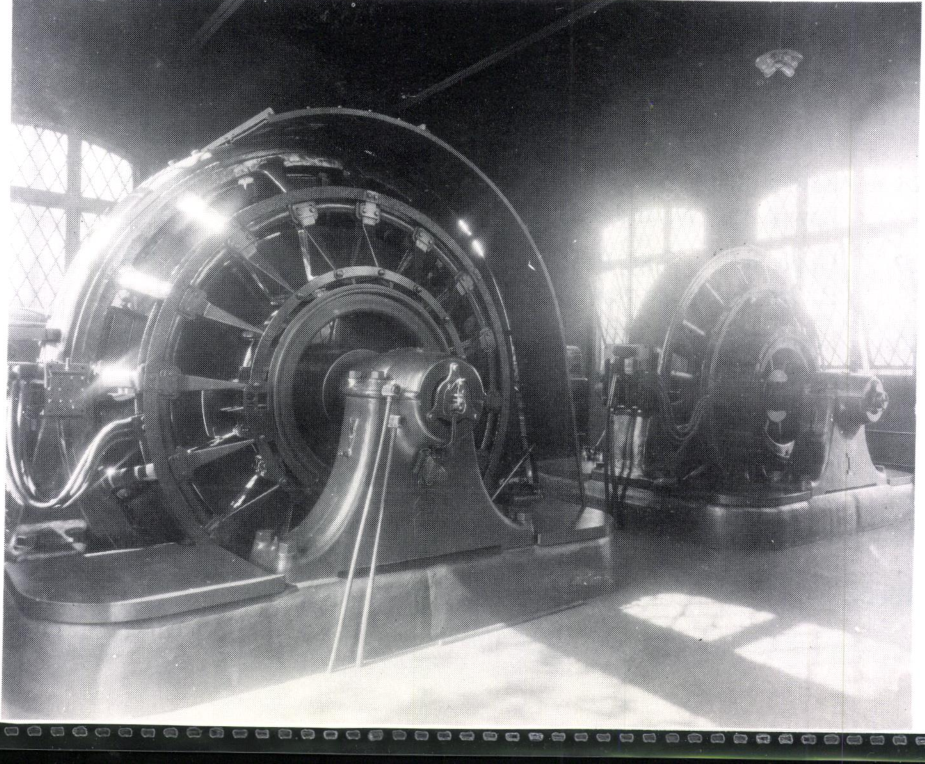
Eleventh and Hennepin Streets Substation, Twin City Rapid Transit Company
Minneapolis, Minn.
Four 1500 Kw. G.E. Rotary Converters


he Gl
for th
who wish
Cor. Sever

A view of the typical substation: Hope St., St. Paul.



6-5-1909



Interior of a typical two 1500 KW rotary converter substation.

(Both photographs A. D. Roth; Robert Bowes collection)

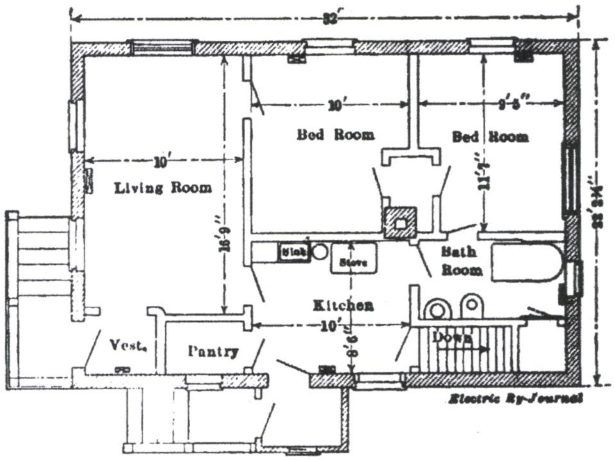
EAJ

HOUSE FOR SUBSTATION OPERATOR

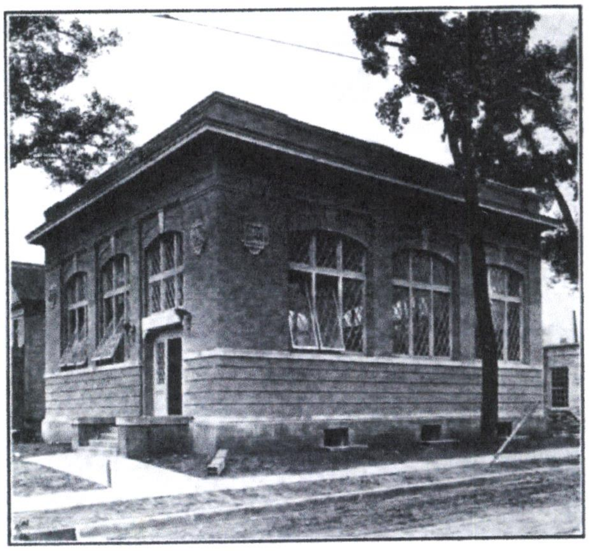
9-27-1913

The accompanying plan shows the living floor of a two-story house recently erected at the rear of the Girard Avenue substation lot in Minneapolis by the Twin City Rapid Transit Company. The other floor is a basement, containing laundry, heater room and storeroom, and the house is rented to the substation operator at the nominal price of $10 per month. The building is of brick and is designed to accord with the style of the substation, which is a very handsome brick structure. It measures 22 ft. x 32 ft., outside, and is placed at the extreme rear of the substation lot to allow room for an attractive, pleasantly shaded yard between it and the substation. While primarily designed for two floors only, another story could be added without great cost. As the plan indicates, the details have been worked out with regard to the convenience of the occupants and economy of space, and as a result the substation operator has for a nominal rent what would be an expensive flat in an apartment house.

The Twin City Rapid Transit Company has had some experience with the plan of renting apartments to substation operators and finds that fewer operators are required when the chief operator lives on the premises, as he is able to give better supervision to the station and is available for emergency calls without delay. [redacted]



Plan of Living Floor for Twin City Substation Operator



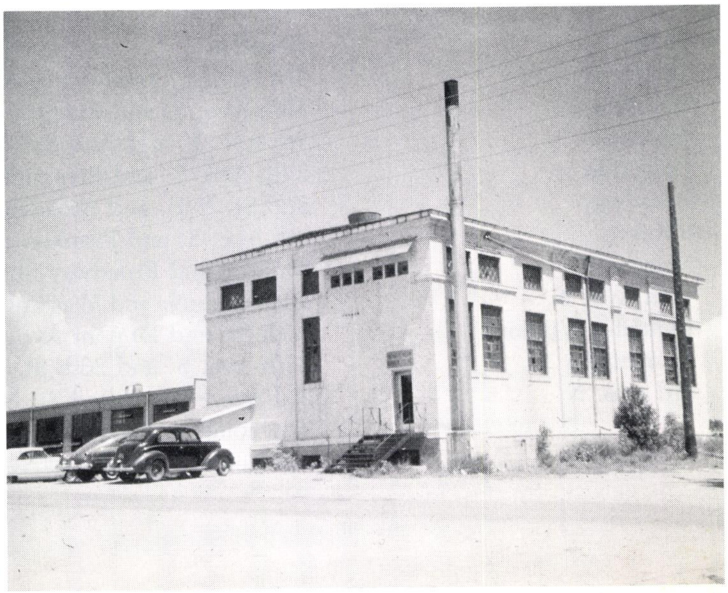
Typical Substation, Twin City Rapid Transit Company

1913

[redacted]: The Wildwood Substation as it appeared in 1936 having been out of service for several years. (Minnesota Historical Society collection)

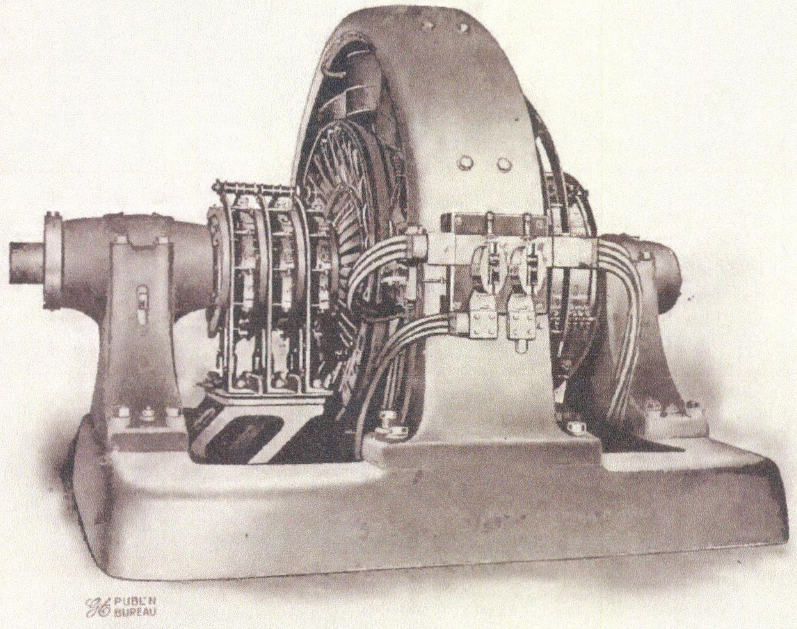
Below left: A view of the Wildwood Terminal House after grading for the highway removed the wooded hill between the substation and the right-of-way.

Below right: A view of the Hopkins substation many years after it had been removed from service.



General Electric Company

Rotary Converters
FOR
Electric Railway Service



H. C. 8-1000-375, 600-Volt Compound-Wound Rotary Converter.

General Electric Rotary Converters are noted for their reliable and stable operation even under all momentary abnormal conditions of load, voltage and frequency.

Endorsed by Managers of the Leading Electric Railways.

This is what one satisfied manager says:

"The commutation of the machines is apparently entirely satisfactory, taking swing loads up to 250% of their capacity without sparking and running on a variation of A. C. voltage amounting in some instances to 30% and a variation in frequency of 20%."

1515

Chicago Office:
Monadnock Bldg.

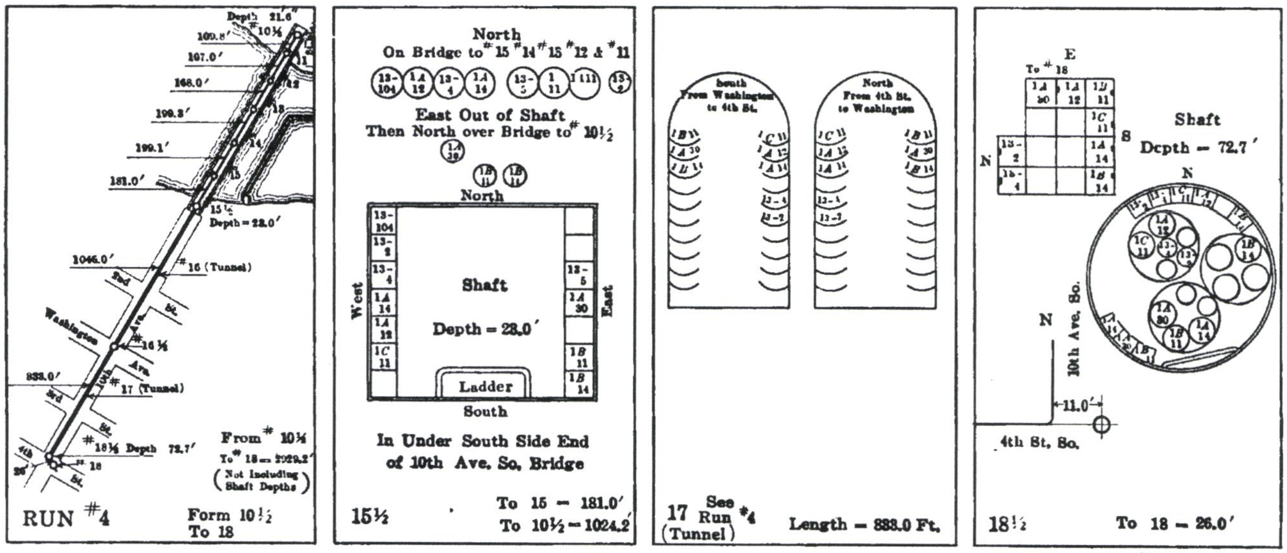
Principal Office:
Schenectady, N. Y.

Sales Offices in
all large cities

POWER DISTRIBUTION ON THE TWIN CITY SYSTEM

The steam power plant which supplements the output of two water-power plants from which the system of the Twin City Rapid Transit Company is supplied with power has been undergoing material changes. The plant originally contained four 5000-hp vertical reciprocating engines, which have been replaced by one 14,000-kw turbine and three 15,000-kw turbines, and the space originally planned for a fifth engine has been occupied by two 5000-kw turbines for the past eight years. The distributing system has also been improved by the addition of two new substations, Girard and University, while new equipment has been installed in the Snelling substation to replace that removed to furnish the newer and smaller substations. As the system as a whole is in excellent form to handle the rapidly increasing demands for power and as the distribution system has never been fully described, some details are given in the following paragraphs.

In the first place it should be noted that the power situation in the Twin Cities is rather unusual. The Mississippi River flows through both cities and in Minneapolis falls about 70 ft. in a distance of half a mile. While the flour mills have prior rights to a part of the available water-power, there is still enough water for several thousand kilowatts left for the railway company. The company utilizes the full flow of the river at a head of from 16 ft. to 20 ft. in the "lower dam" plant and also the surplus available at St. Anthony Falls above that required by the flour mills at about 50-ft. head. The railway company also has a 60,000-kw supplementary steam plant located close to the water-power plants. The power generation is thus concentrated at a central point convenient for transmission in all directions. The district served covers an area 16 miles by 48 miles in extent, containing a population of 600,000 and served by 402 miles of track.



Depth 21.6″
#10¾
100.8′
107.0′
168.0′
199.3′
199.1′
181.0′
15½
Depth = 28.0′
1046.0′
#16 (Tunnel)
2nd
St.
Washington
Ave.
#16½
Ave.
10th
833.0′
#17 (Tunnel)
3rd
St.
#18½ Depth 72.7′
#18
4th
26′
St.
From # 10¼
To # 18 = 2029.2′
(Not Including Shaft Depths)
RUN #4
Form 10½
To 18
North
On Bridge to #15 #14 #13 #12 & #11
East Out of Shaft
Then North over Bridge to # 10½
North
West
Shaft
Depth = 28.0′
East
Ladder
South
In Under South Side End of 10th Ave. So. Bridge
15½
To 15 – 181.0′
To 10½ – 1024.2′
South From Washington to 4th St.
North From 4th St. to Washington
17 (Tunnel)
See Run #4
Length – 888.0 Ft.
E
To #18
N
S
Shaft
Depth – 72.7′
N
N
10th Ave. So.
11.0′
4th St. So.
18½
To 18 – 26.0′
Electric Ry. Journal

Twin-City Power Distribution—Sample Pages of Loose-Leaf Record for Feeders

Substation Equipment, Twin City Rapid Transit Company

Substation	Location	No. of Rotaries	Capacity of Rotaries Each	Capacity of Rotaries Total
11	Eleventh Street	5	1,500	7,500
13	Lower dam power plant......	4	600	2,400
14	Lake Street	2	1,500	3,000
15	College Avenue	5	1,500	7,500
16	Snelling Avenue	2	3,000	6,000
20	Wildwood	2	600	1,200
21	Stillwater	2	600	1,200
23	Hopkins	3	600	1,800
25	Excelsior	3	600	1,800
28	Thirty-second Avenue	2	1,500	3,000
29	Hope Street	2	1,500	3,000
30	Minnehaha	2	1,500	3,000
31	University	2	1,500	3,000
32	Girard Avenue	2	1,500	3,000
	Total			47,400

There are, in addition to the city lines, four interurban lines connecting the Twin Cities and two suburban lines, one running to Stillwater and South Stillwater, the other west to Excelsior and Deephaven. Fourteen substations are now in operation with the equipment shown in the table.

With the exception of the new 3000-kw units in the Snelling Avenue substation, the rotary converters are all of the non-interpole type. Barring a few of the 600-kw size, they are all six-phase. The frequency of the system is thirty-five cycles, and the transmission voltage is 13,200. Air-blast transformers are used in all substations.

The latest substation put into commission is the one on Girard Avenue, and, while substation construction is now so well standardized that a detailed description is unnecessary, a few points in connection with this one will be mentioned. The general arrangement of the station is standard as far as the placing of converters, reactances, transformers, oil switches, blowers, etc., is concerned. The cells for the oil switches are of concrete, cast in place in sections of three, six or nine. Alberene stone slabs, 2 in. thick, are placed on top of the cells. The high-tension bars are of ⅝-in. round copper. They are placed in the basement below the switch cells and are not inclosed.

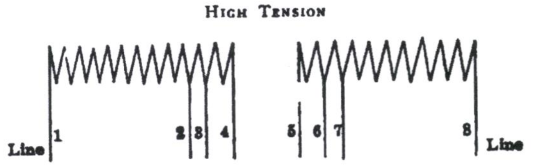
In spite of the large size of the rotaries, due to their being of the non-interpole type, the capacity of the substation is good for its size, 44 ft. x 44 ft. outside. The capacity can be doubled without great expense by extending the rear, space having been reserved for this purpose between the building and the operator's residence which the company has constructed at the back of the lot.

At the Snelling substation, about midway between the centers of St. Paul and Minneapolis, 1500-kw rotaries have been replaced by the latest type of G. E. 3000-kw commutating-pole machines. These occupy no more space than their predecessors. The commutating poles are provided with two windings, the usual series coils and an auxiliary adjusting shunt winding. The series coils have the usual resistance and inductive shunts. The rotaries have fourteen poles and operate, therefore, at 300 r.p.m. on thirty-five-cycle current. A new type of air-blast transformer having no outside casing is used. The direct exposure of the active iron to the outside air assists the ventilation. These transformers are rated at 1050 kva each and are provided with 15 per cent reactance. Ventilating air at 1⅛ ounces pressure is furnished by a duplicate blower set located in the basement.

Digitized by Google

The transformer connections are arranged for multiple-voltage starting of the rotaries, the secondaries being divided into eight sections, as shown in the accompanying diagram, so as to give 143, 215, 286 and 430 volts. Of these voltages 143, 286 and 430 are used in starting by manipulation of switches on the low-tension board. The high-tension side has taps for five voltages between 12,500 and 11,250. In addition to the rotary converter equipment this substation, which is adjacent to the large car shops of the company, contains two 300-kw induction-motor d.c. generator sets to provide shop power. The motors take three-phase a.c. power from the low-tension side of the transformers at from 430 volts to 440 volts, and the generators, which are of the three-wire type, deliver direct current at 220 volts between outside wires, 110 from each to neutral.

In all but a few of the high-tension lines from power house to substation more than one connection is furnished, the exceptions being at points where substations can assist each other over the d.c. lines. Three-conductor cable is used, and No. 0000 is the standard size of wire. The cable system is so extensive that a card catalog for keeping track of it has been devised. Each cable section has its history recorded separately, and the record is kept up to date. By the use of the plan of using few sizes and keeping close watch of the condition of the cables it has been found possible to provide for emergencies with a stock of reasonable size. At the substations home-made pot-heads of spun copper are used with entire satisfaction.



Volts	Amps.	Join taps
12,500	84.0	4 and 5
12,190	86.1	4 and 6
11,875	88.4	3 and 6
11,565	90.8	3 and 7
11,250	93.3	2 and 7

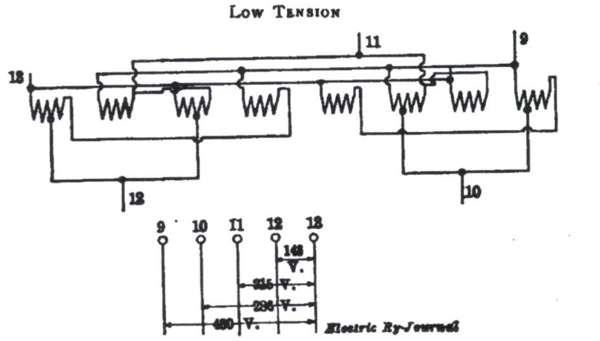
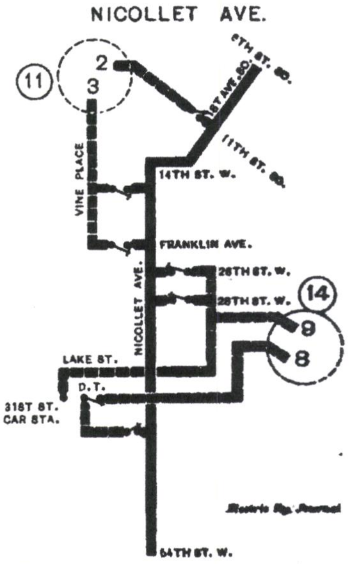


Diagram and Table of Transformer Connections, Snelling Avenue Substation

In the lower dam power plant the eight a.c. generators are divided into two equal groups, and the corresponding busbars are connected by sectionalizing switches. Jumpers are provided on two units in each section by means of which they can be connected direct to rotary converters, cutting out the busbars entirely. In the Hennepin Island plant the four generating units are divided into two equal sections also. In the steam plant the switching arrangements are more elaborate. The generators buses for the one 14,000-kw and two 15,000-kw turbine units are in three sections with sectionalizing switches between. The two 5000-kw turbine units and the one 3500-kw engine unit are paralleled on a separate bus section. Three feeders are taken off from each large turbine bus and four from the small turbine-engine bus. There are also two separate sets of feeder buses. By means of a double set of switches connected to each large turbine unit these may be connected around their own buses to the separate feeder buses and the small turbine-engine unit buses respectively. By this very complete system of interconnection of busbar sections any desired combination of feeds and generating units can be obtained. Motor-driven exciters are operated from two different bus sections, to one of which is also connected a large neutral-grounding transformer. This is used because delta connection of transformers is used in the old lower dam plant, which may, at times of light load, be called upon to carry it all, thus leaving the lines without any grounding connection. A 600-kw, three-phase, oil-cooled transformer with primary star-connected and secondary delta-connected is grounded at the neutral and used for this purpose.

ERJ 9-28-1912

TWIN CITY FEEDER CONNECTION DIAGRAM



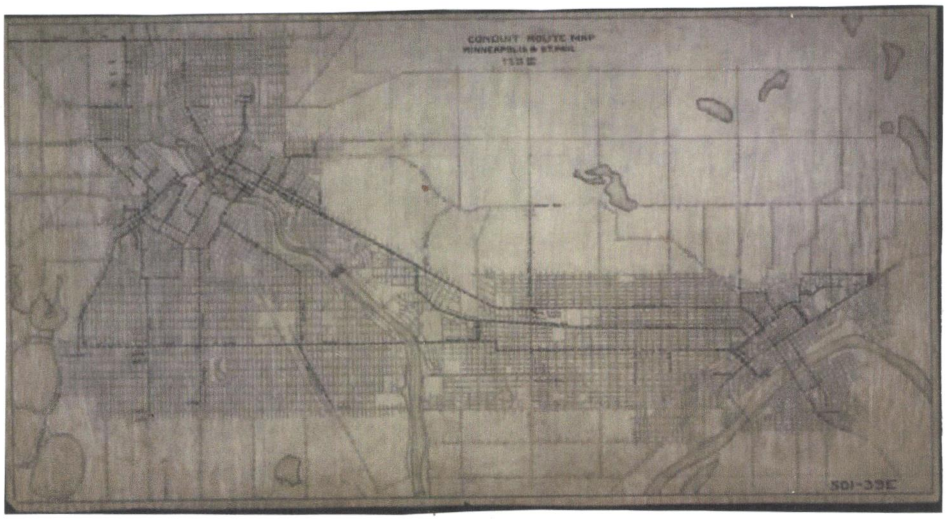
Twin City Typical Feeder Layout

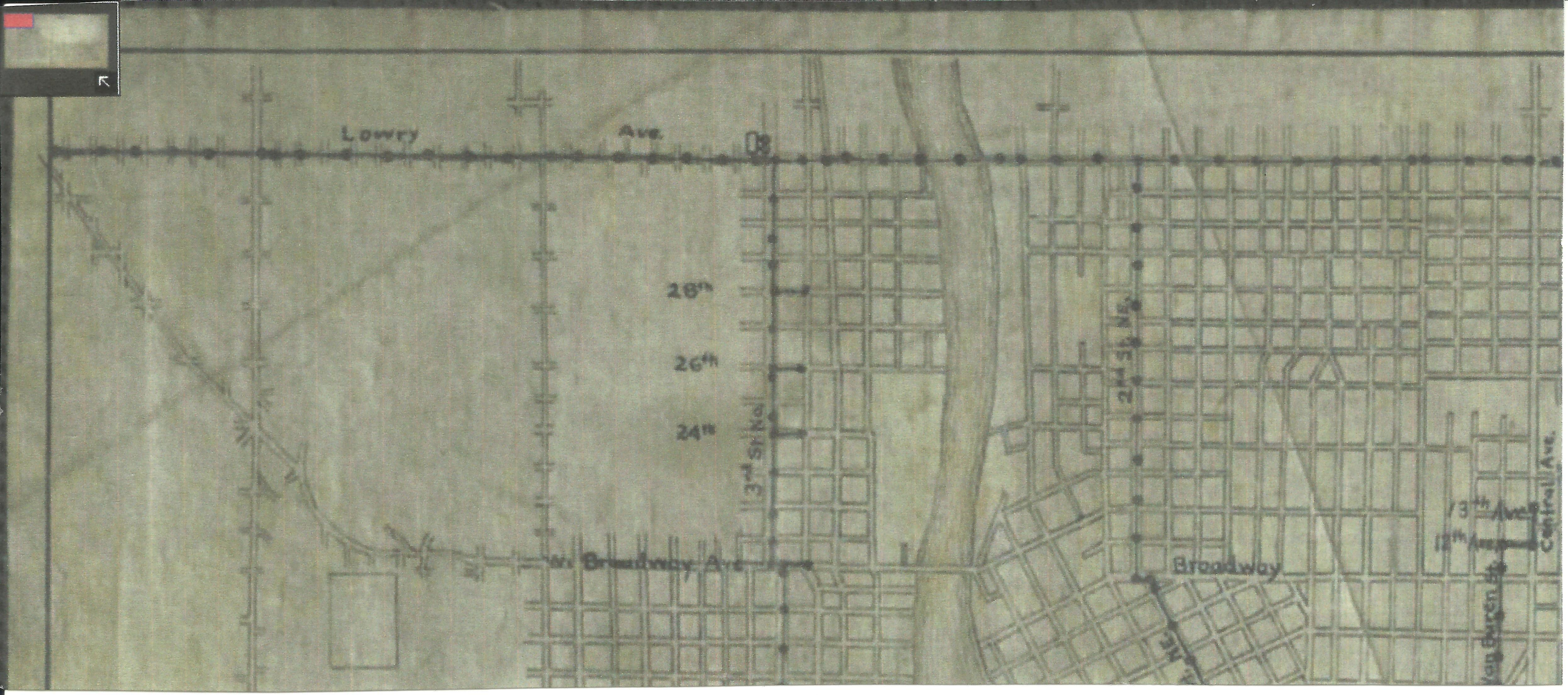
The power and equipment department of the Twin City Rapid Transit Company, Minneapolis, Minn., has recently devised a new method of advising the different substation operators of the possible connections that can be made through any given feeder panel. The method of conveying this information is by inclosing in a small frame on the switchboard a diagram showing in heavy black lines the existing lines fed through a given panel, and in dotted lines possible connections with switches noted at the various other stations which can be thrown in, connecting the panel with new feeder sections. One of the diagrams is mounted on each feeder panel at every substation. A typical diagram is shown in the illustration.

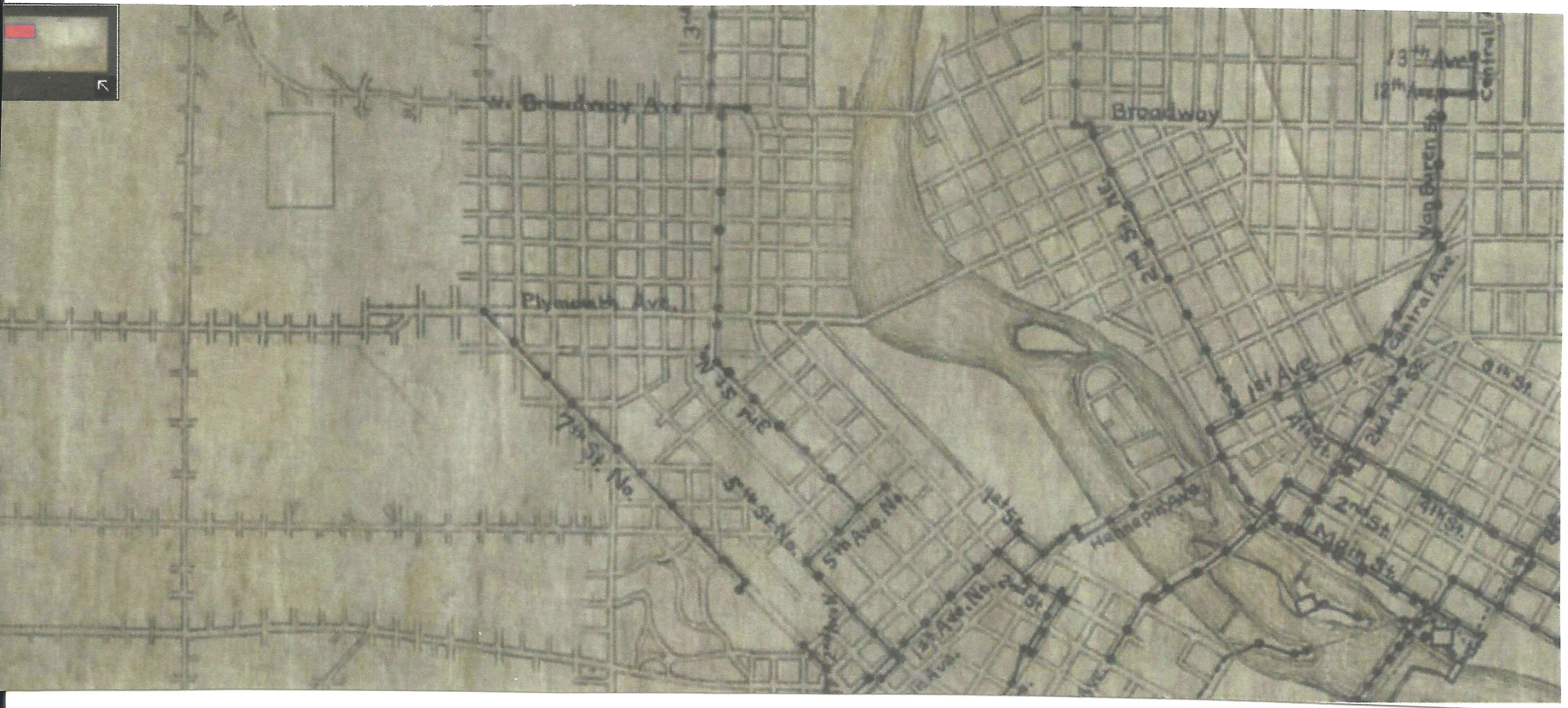
Digitized by Google

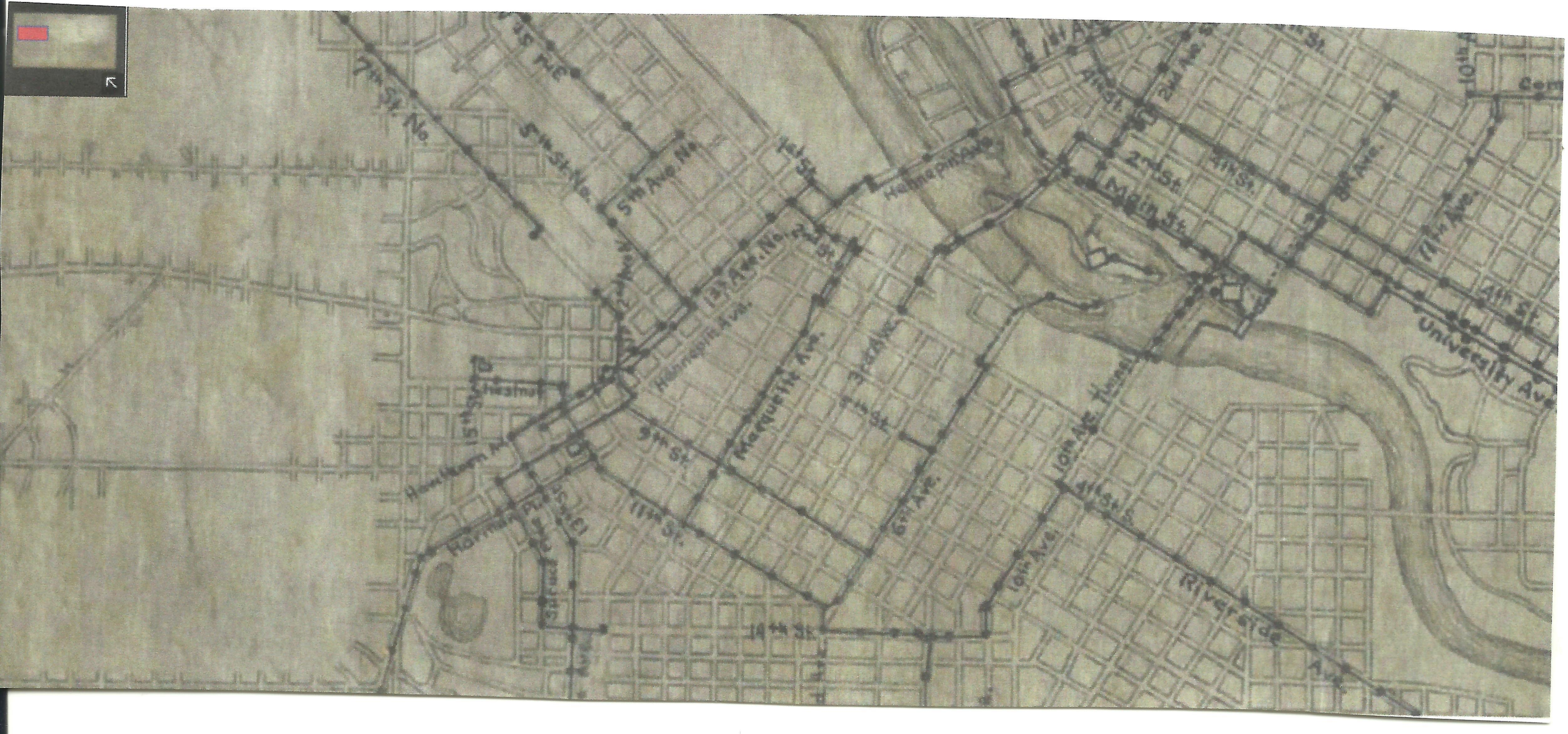
CONDUIT ROUTE MAP
6-5-1920
1-13-1925

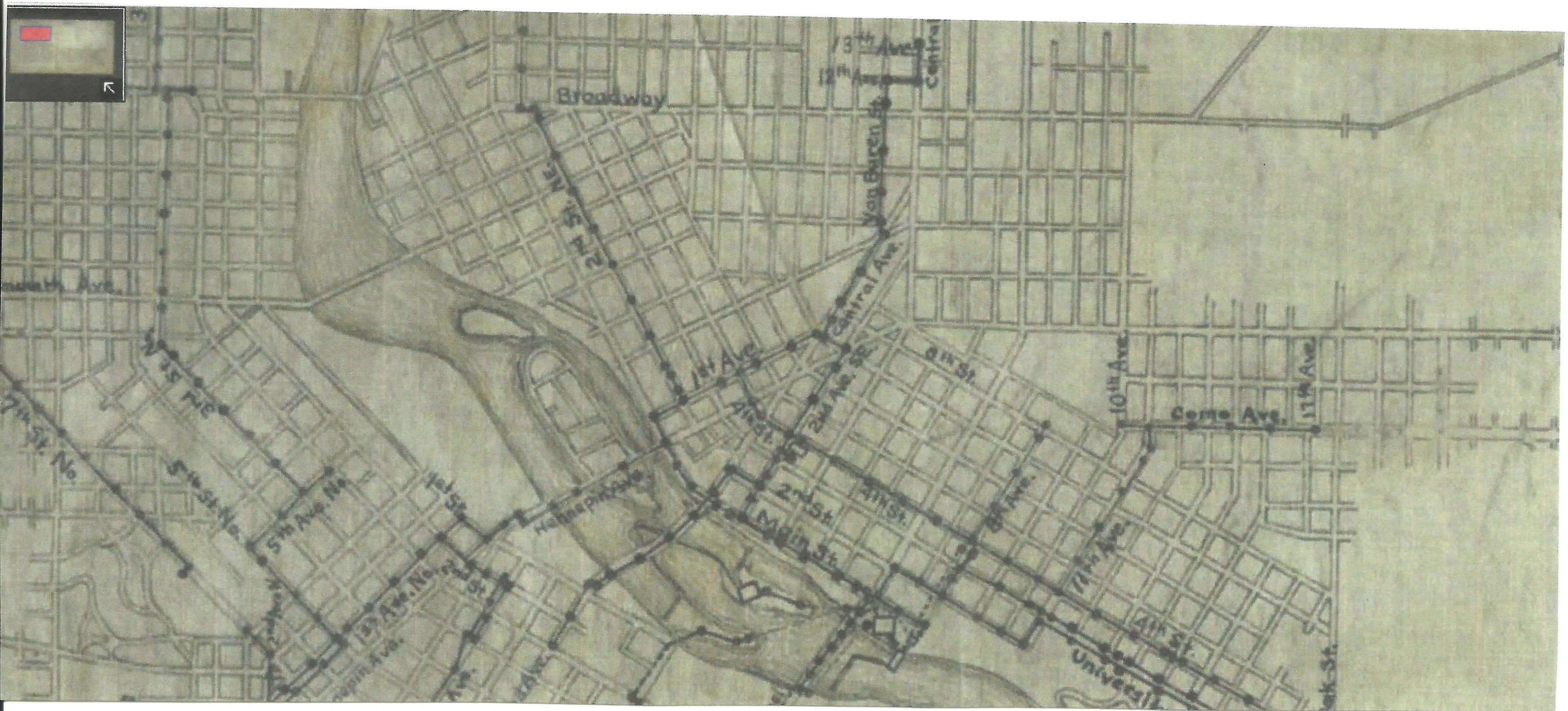
Original is in the collections of the Minnesota Streetcar Museum. Digitized copy is in the MSM Collection on Minnesota Reflections website. For research purposes I printed enlarged sections of the website copy. Sections overlap because of the printing process; all the conduits on the map are included.

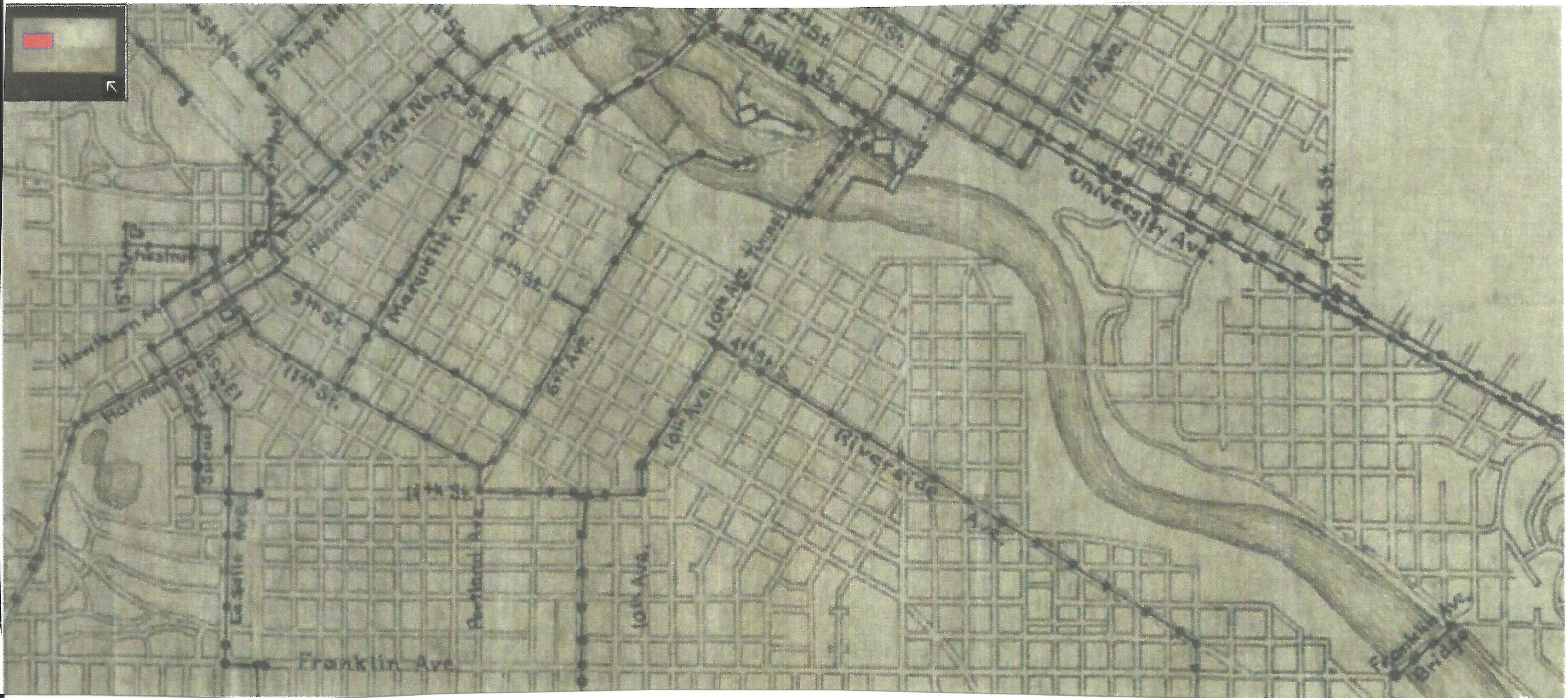

CONDUIT ROUTE MAP
MINNEAPOLIS & ST.PAUL
501-33E

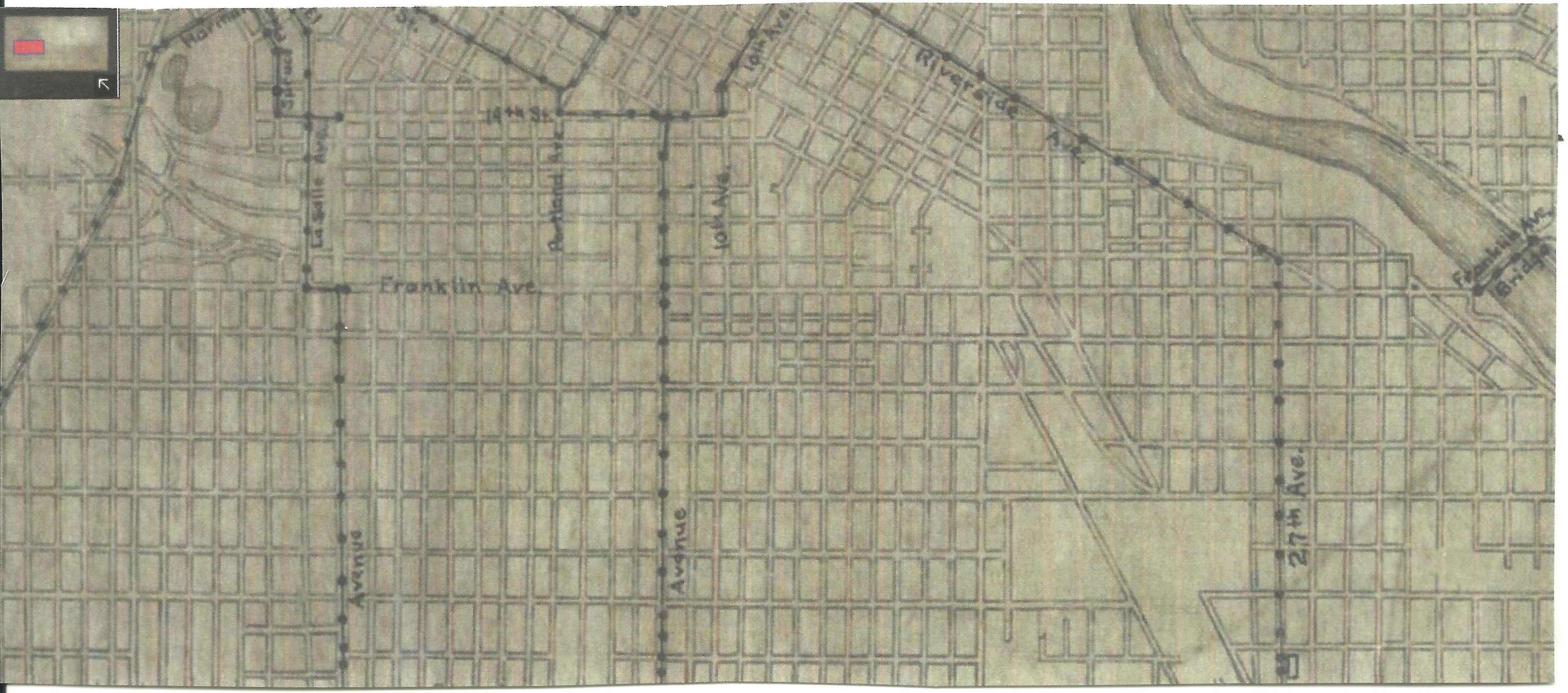

Lowry Ave.
28th
26th
24th
3rd St. No.
2nd St. NE.
W. Broadway Ave
Broadway
13th Ave.
12th Ave.
Central Ave.
Van Buren St.

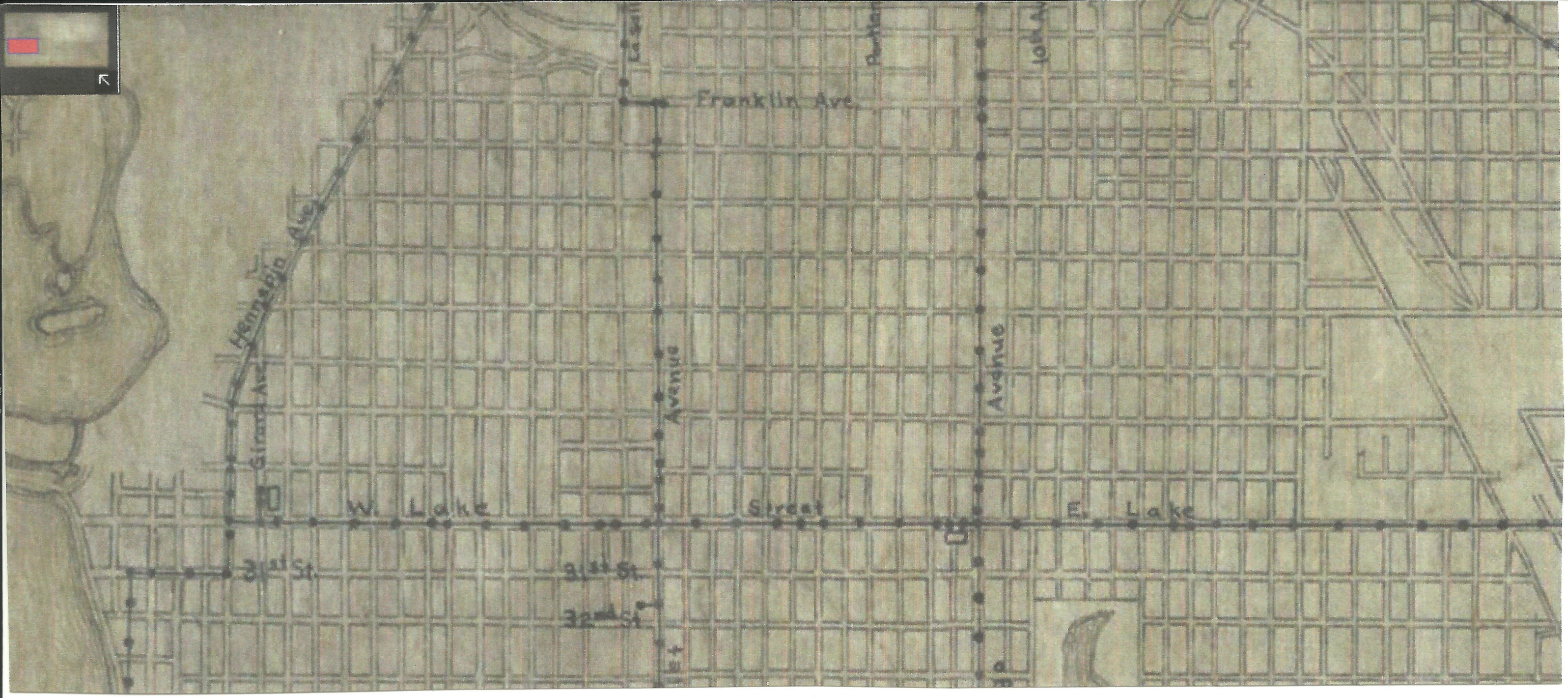

W. Broadway Ave
Broadway
13th Ave.
12th Ave.
Central Ave.
Van Buren St.
Plymouth Ave.
7th St. No.
5th St. No.
3rd St. No.
5th Ave. No.
1st St.
2nd St. NE.
1st Ave.
4th Ave.
2nd Ave. SE.
8th St.
Central Ave.
Hennepin Ave.
2nd St.
4th St.
Main St.
1st Ave. No.
2nd St.

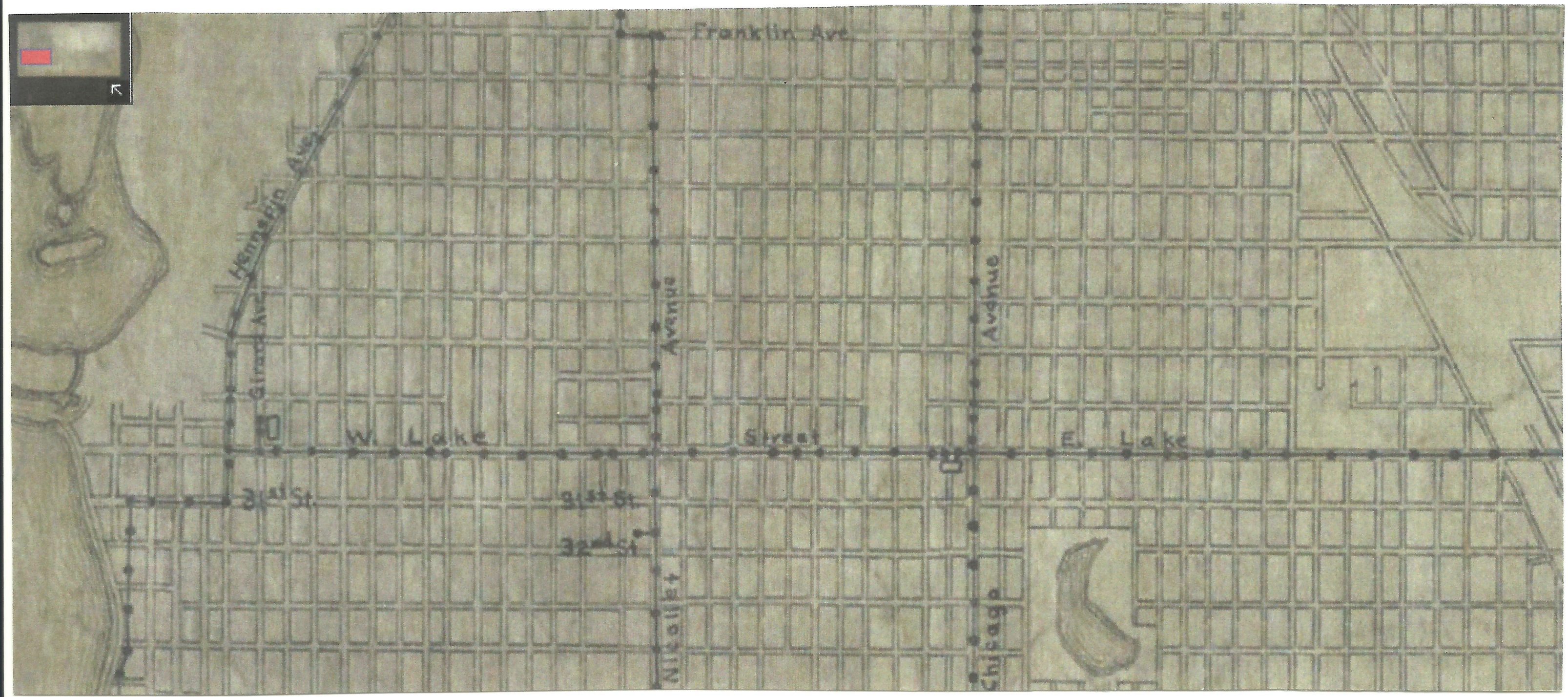

7th St. No.
3rd St. No.
5th St. No.
5th Ave. No.
1st St.
Hennepin Ave.
1st Ave. No.
2nd St.
2nd St.
4th St.
Main St.
8th Ave.
17th Ave.
4th St.
University Ave.
Hennepin Ave.
Marquette Ave.
3rd Ave.
4th St.
Chestnut
15th St.
Hawthorn Av.
9th St.
11th St.
Harmon Pl.
6th Ave.
10th Ave.
4th St. S.
10th Ave.
Riverside Ave.
14th St.

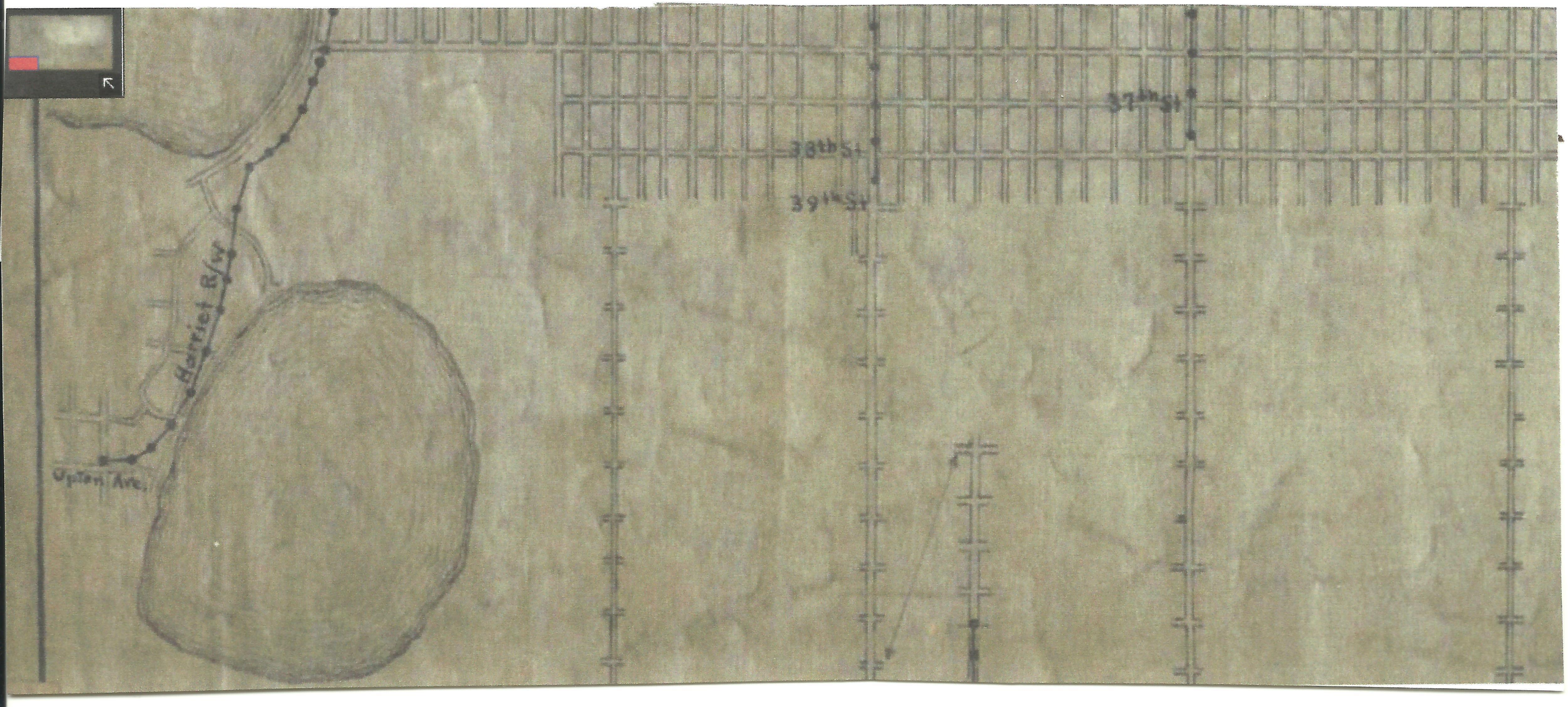

13th Ave.
12th Ave.
Central
Broadway
2nd St. NE
Van Buren St.
Central Ave.
Plymouth Ave.
N 15 Ave.
7th St. No.
5th St. No.
5th Ave. No.
1st St.
1st Ave.
4th St.
2nd Ave. St.
8th St.
10th Ave.
17th Ave.
Como Ave.
Hennepin Ave.
2nd St.
Main St.
4th St.
8th Ave.
17th Ave.
4th St.
University Ave.
Oak St.
1st Ave. No.

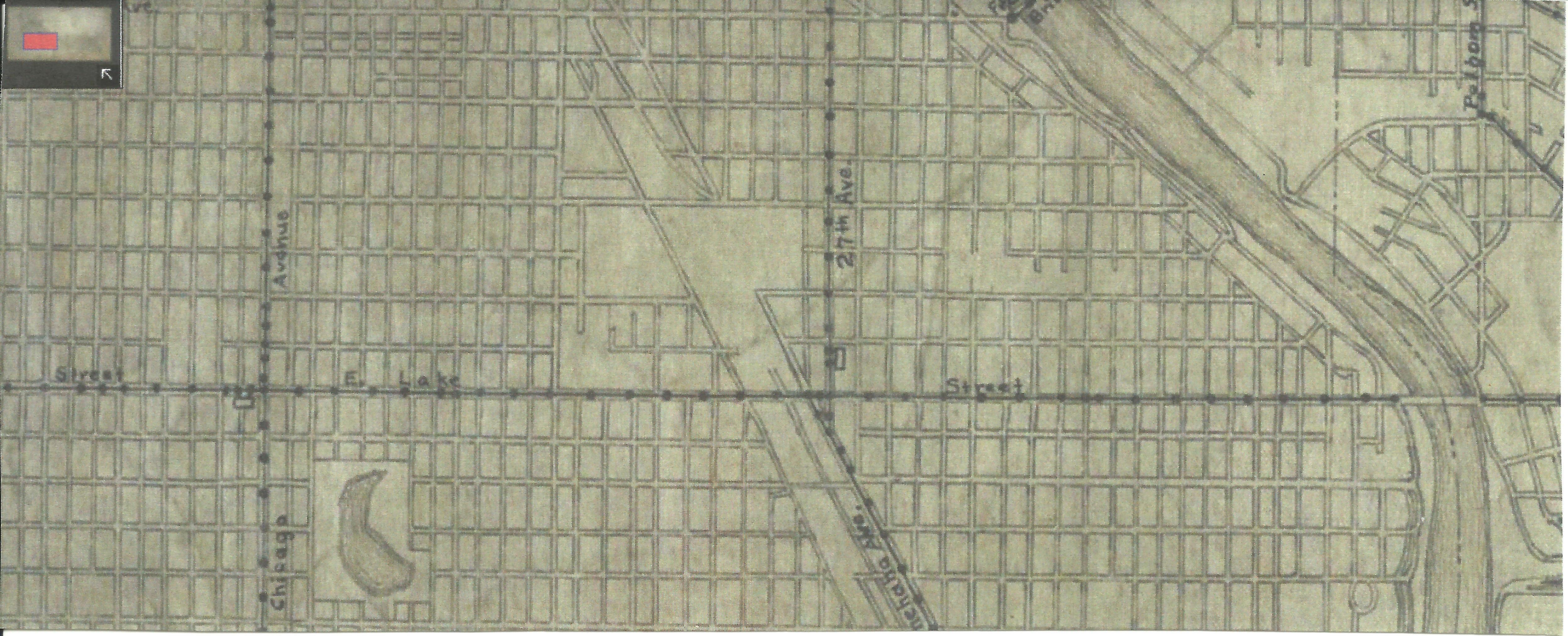

5th Ave. No.
1st Ave. No.
Hennepin Ave.
2nd St.
4th St.
Main St.
8th Ave.
17th Ave.
4th St.
University Ave.
Oak St.
Chestnut
15th St.
Hamilton Av.
Harmon Pl.
Spruce Pl.
Grant St.
Hennepin Ave.
Marquette Ave.
3rd Ave.
9th St.
11th St.
6th Ave.
10th Ave.
4th St. S.
14th St.
Portland Ave.
10th Ave.
10th Ave.
Riverside Ave.
LaSalle Ave.
Franklin Ave.
Franklin Ave. Bridge

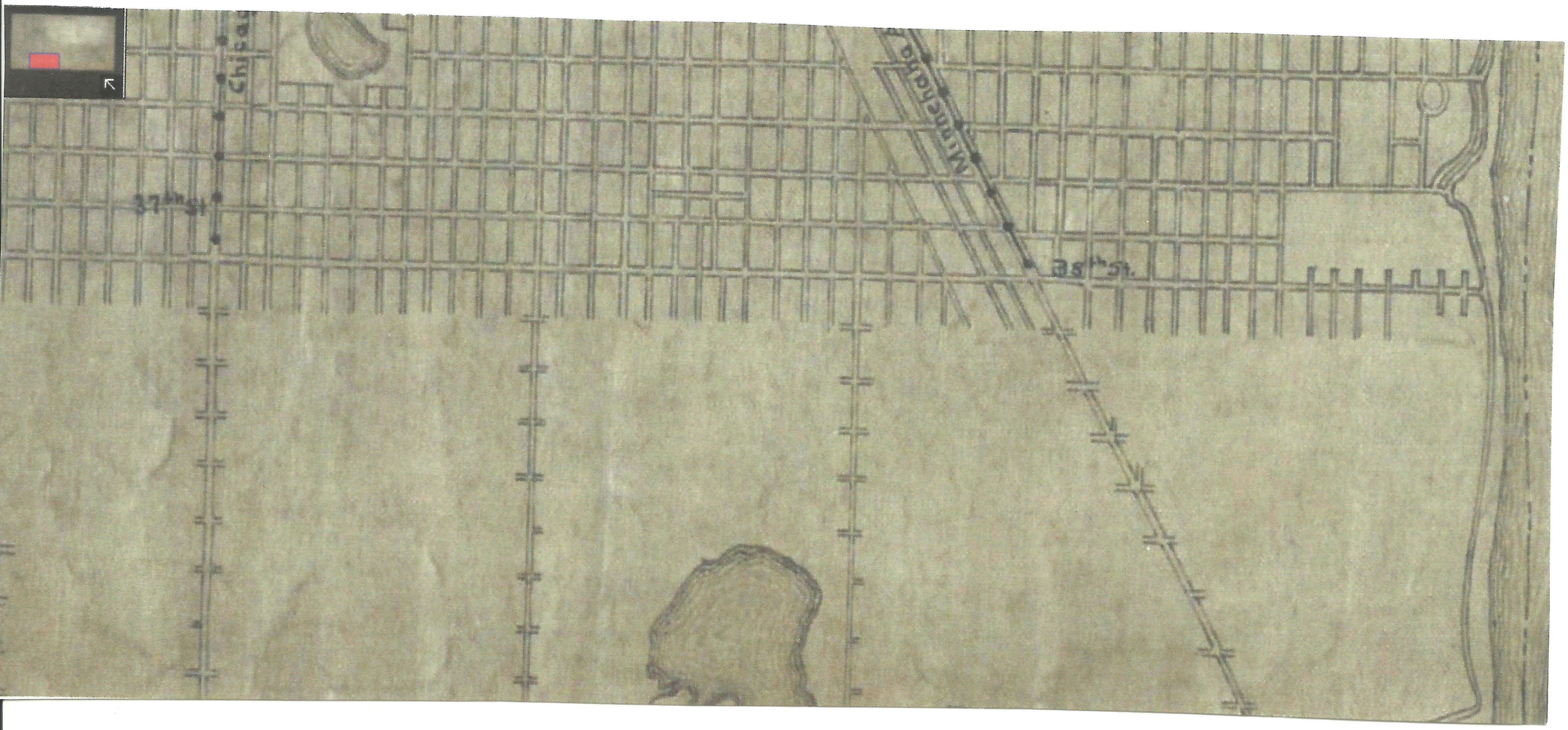

Harmon Pl.
Spruce Pl.
14th St.
10th Ave.
Riverside Ave.
Portland Ave.
10th Ave.
LaSalle Ave.
Franklin Ave.
Franklin Ave. Bridge
Avenue
Avenue
27th Ave.

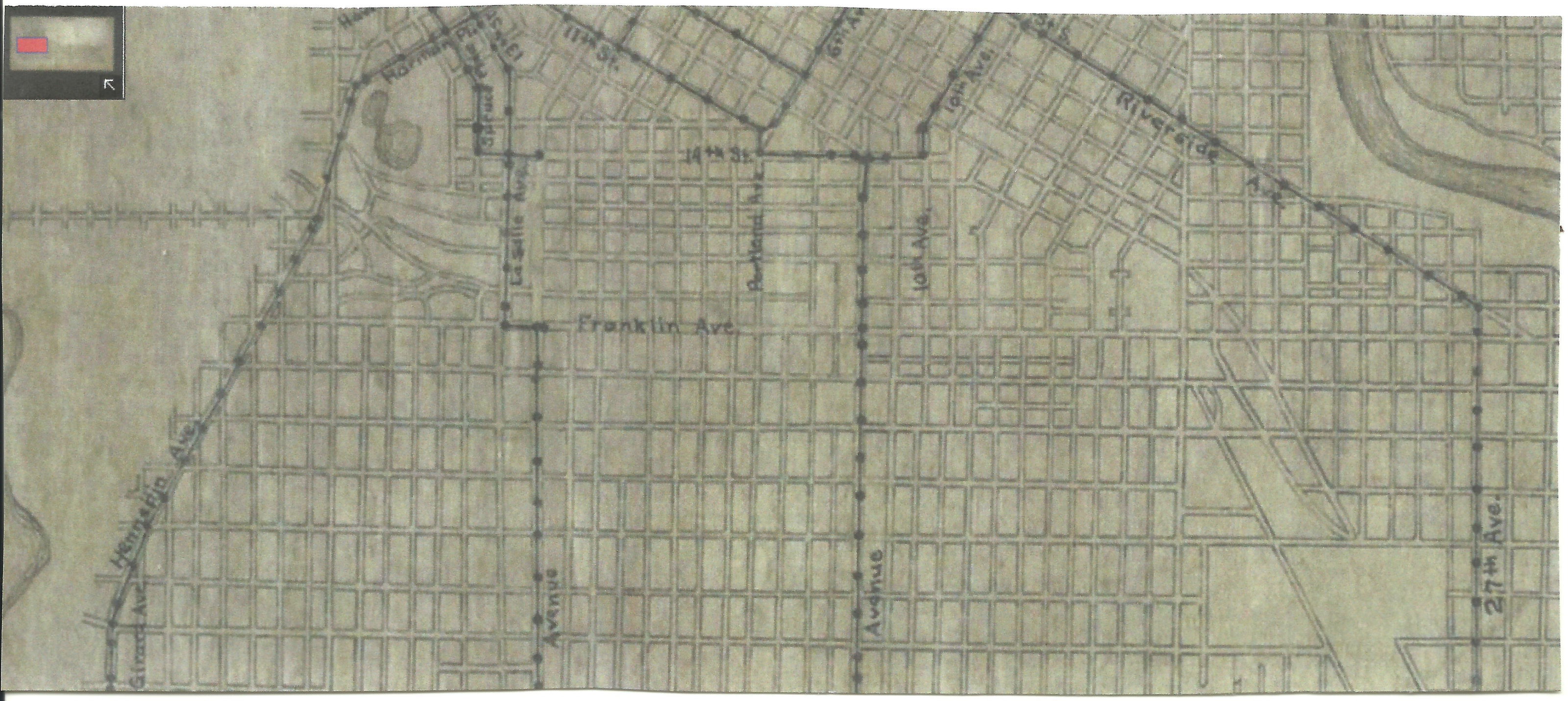

Franklin Ave.
Hennepin Ave.
Girard Ave.
Avenue
Avenue
W. Lake
Street
E. Lake
31st St.
31st St.
32nd St.

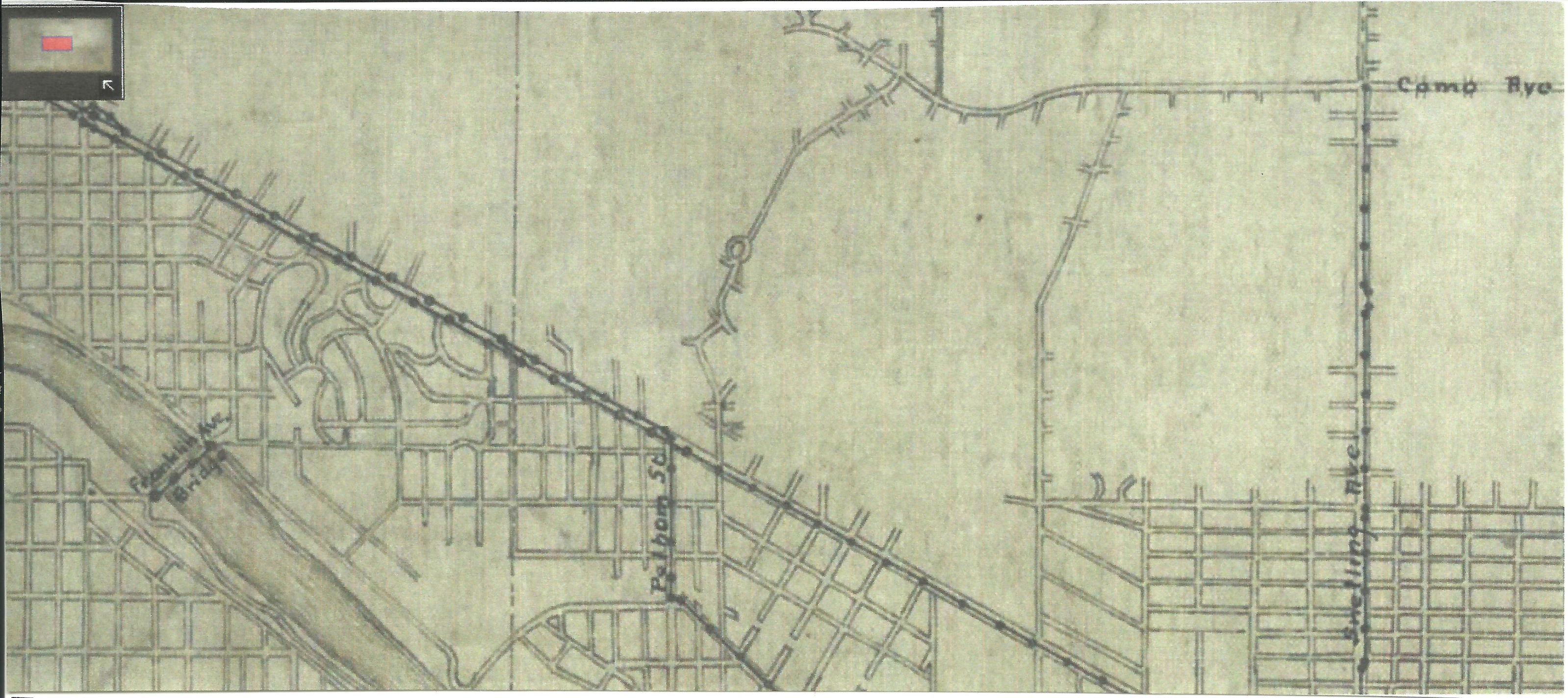

Franklin Ave.
Hennepin Ave.
Girard Ave.
Avenue
Avenue
W. Lake
Street
E. Lake
31st St.
31st St.
32nd St.
Nicollet
Chicago

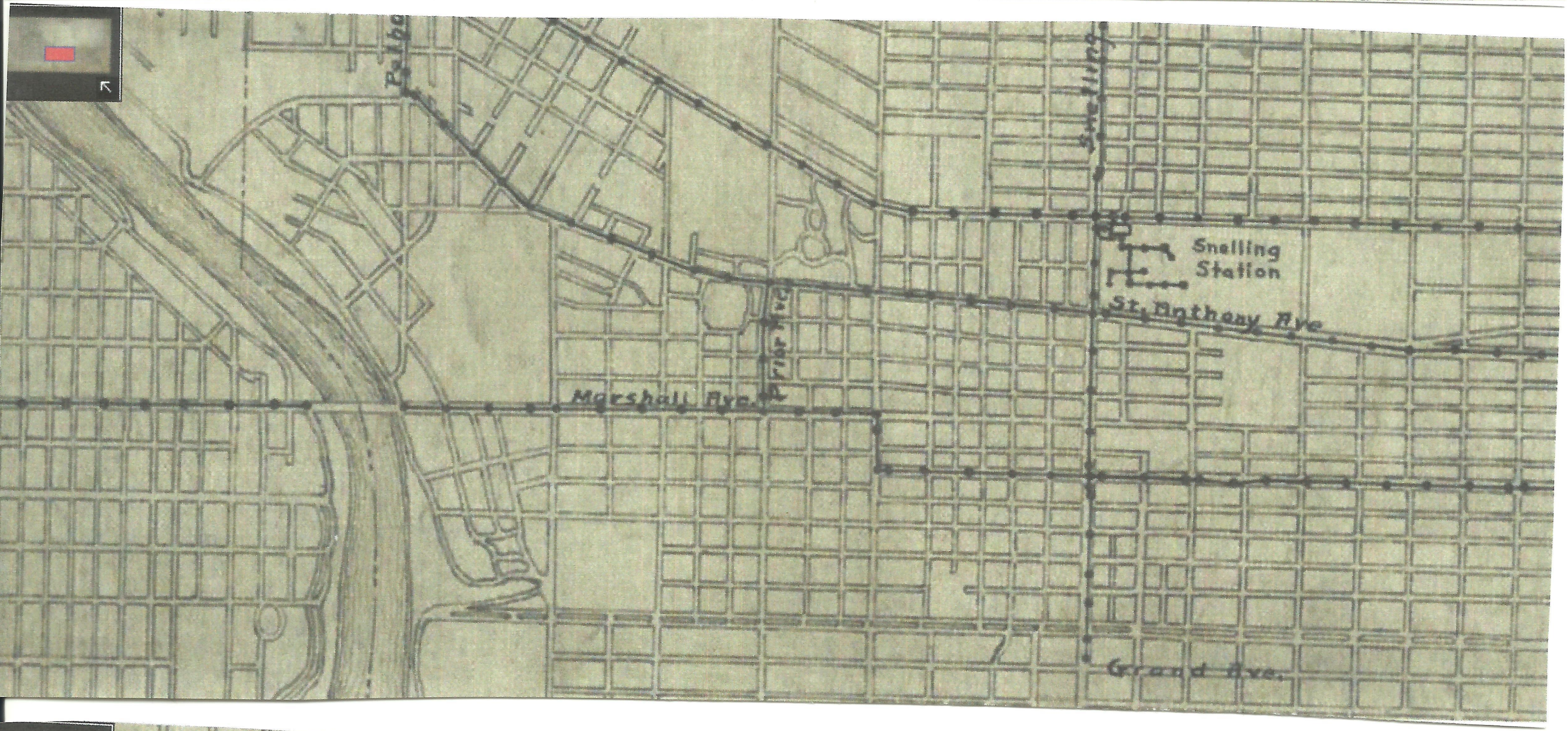

37th St.
38th St.
39th St.
Harriet B/W
Upton Ave.

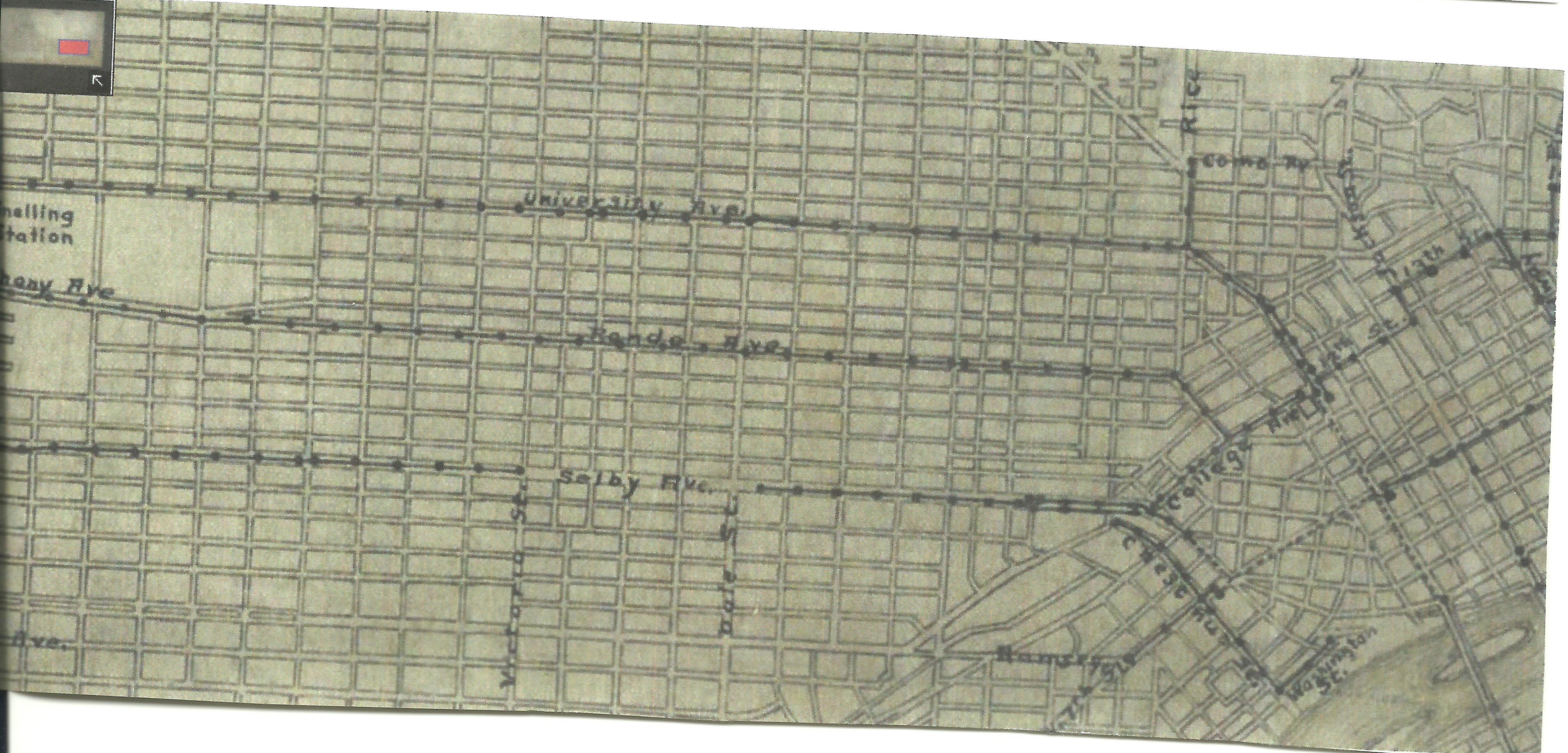

Avenue
Chicago
27th Ave.
Street
E. Lake
Street
Minnehaha Ave.

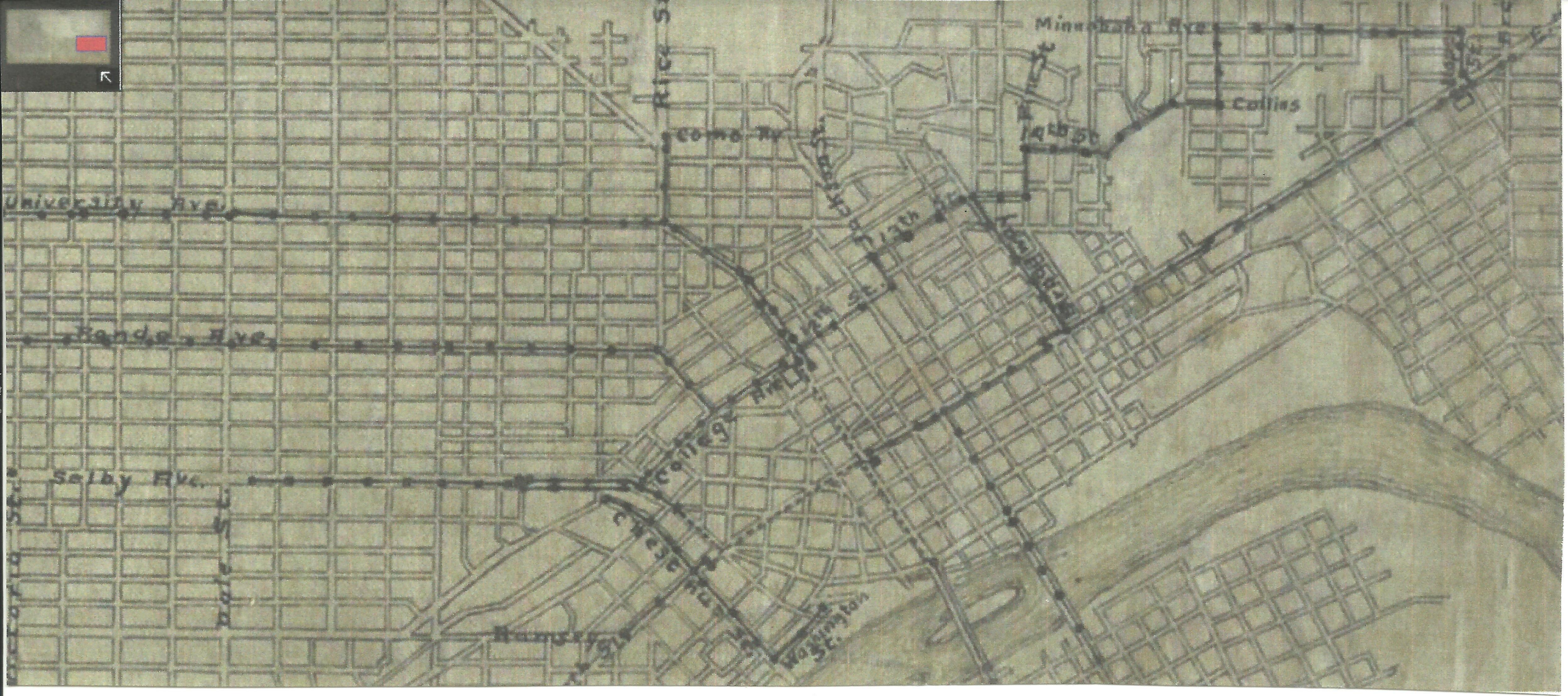

Chicago
37th St
Minnehaha
38th St.

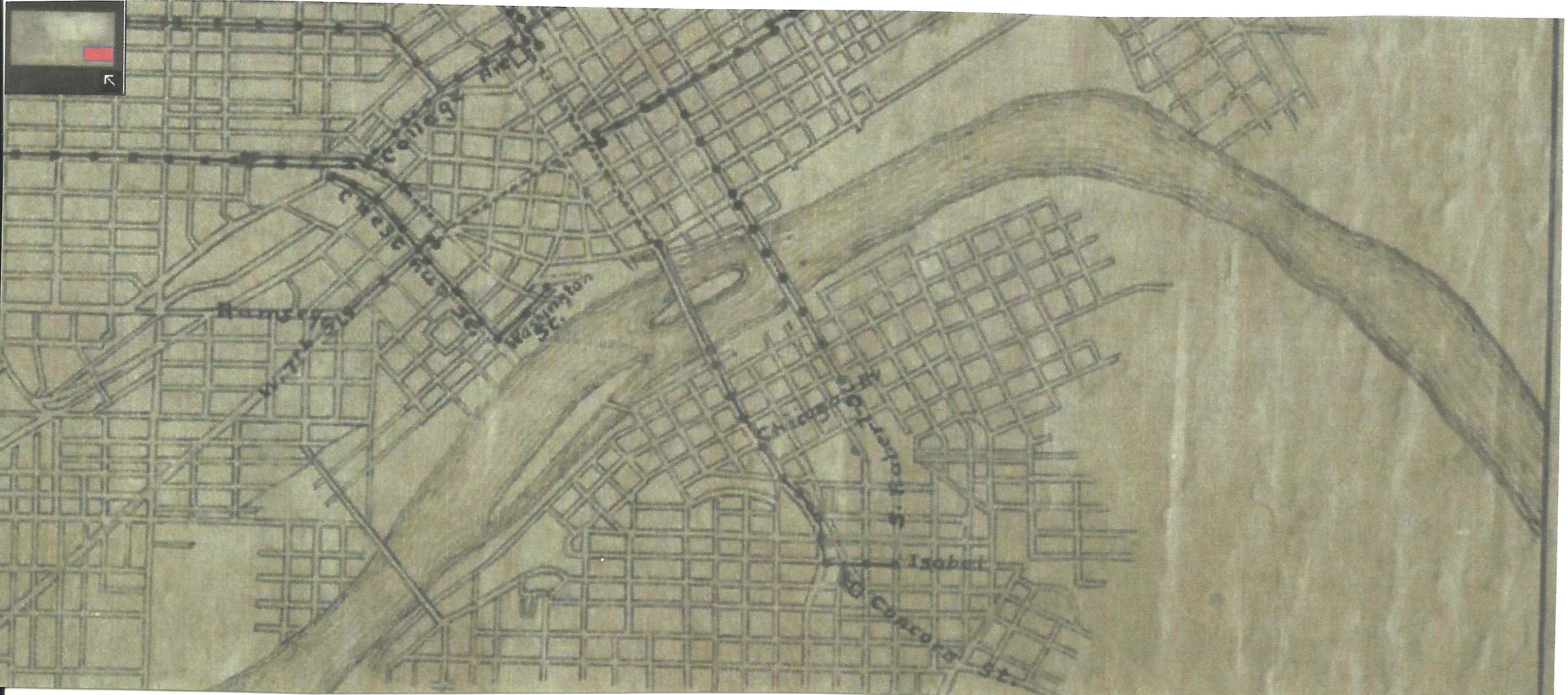

Harmon Place
Spruce Place
11th St.
6th Ave
10th Ave.
14th St.
LaSalle Ave.
Portland Ave.
10th Ave.
Riverside Ave.
Franklin Ave.
Hennepin Ave.
Girard Ave.
Avenue
Avenue
27th Ave.

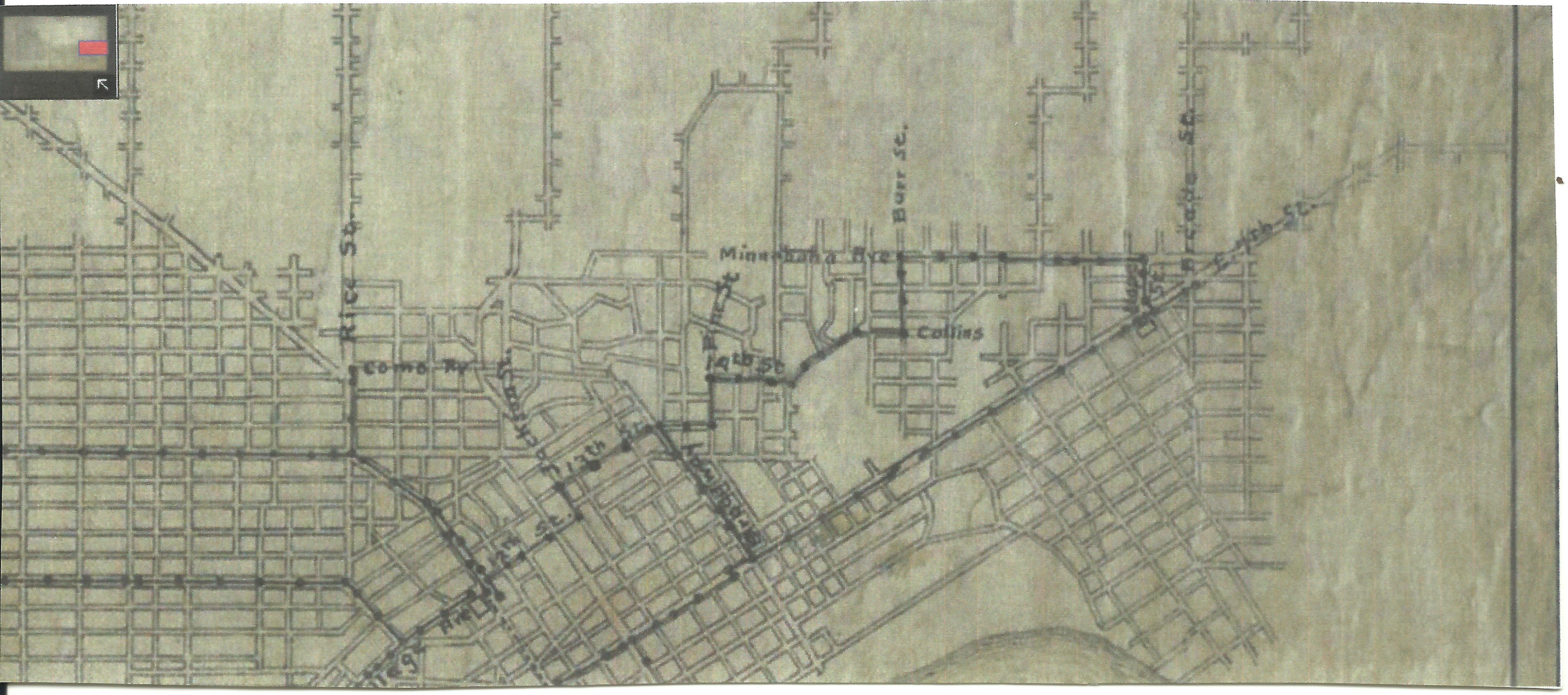

Como Ave
Franklin Ave.
Bridge
Pelham St.
Snelling Ave.


Pelham
Snelling
Snelling
Station
St. Anthony Ave
Prior Ave.
Marshall Ave.
Grand Ave.

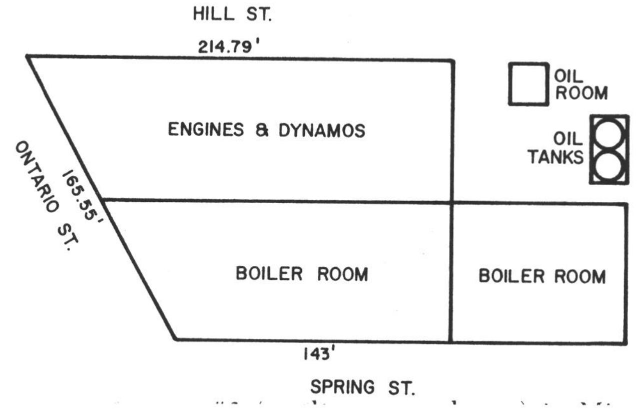

nelling
tation
hony Ave
University Ave.
Rondo Ave.
Selby Ave.
Victoria St.
Dale St.
Ave.
Rice
Como Av
College Ave.
Ramsey
Washington St.


Minnehaha Ave
Collins
19th St
Pine St
Rice St
Como Av
University Ave
Rondo Ave
Selby Ave
Dale St
College
13th St
Jackson St
Ramsey St
Washington St

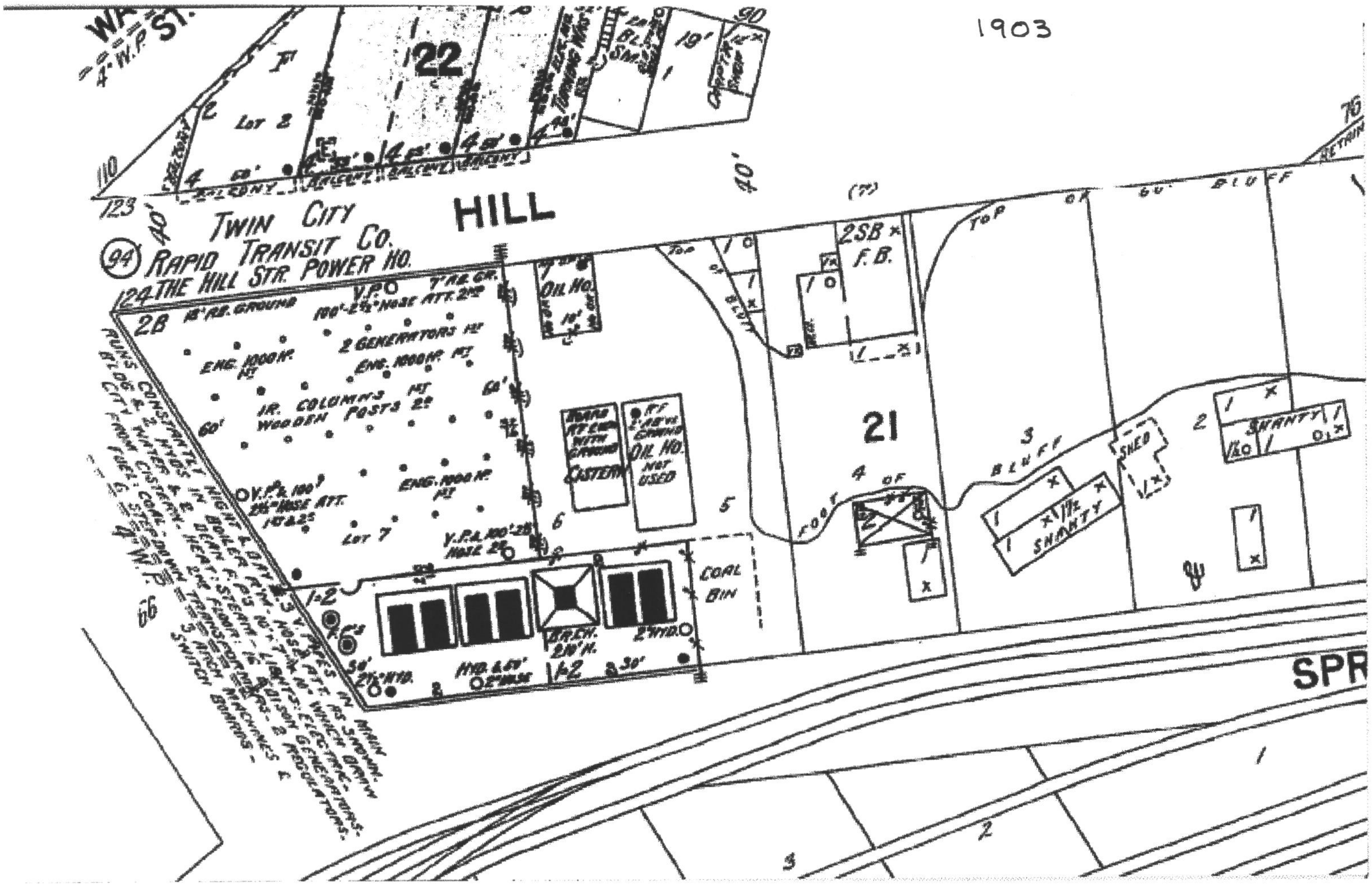

College
Ramsey St
W. 7th St
Washington St
Chicago Av
S. Robert St
Isabel
Concord St

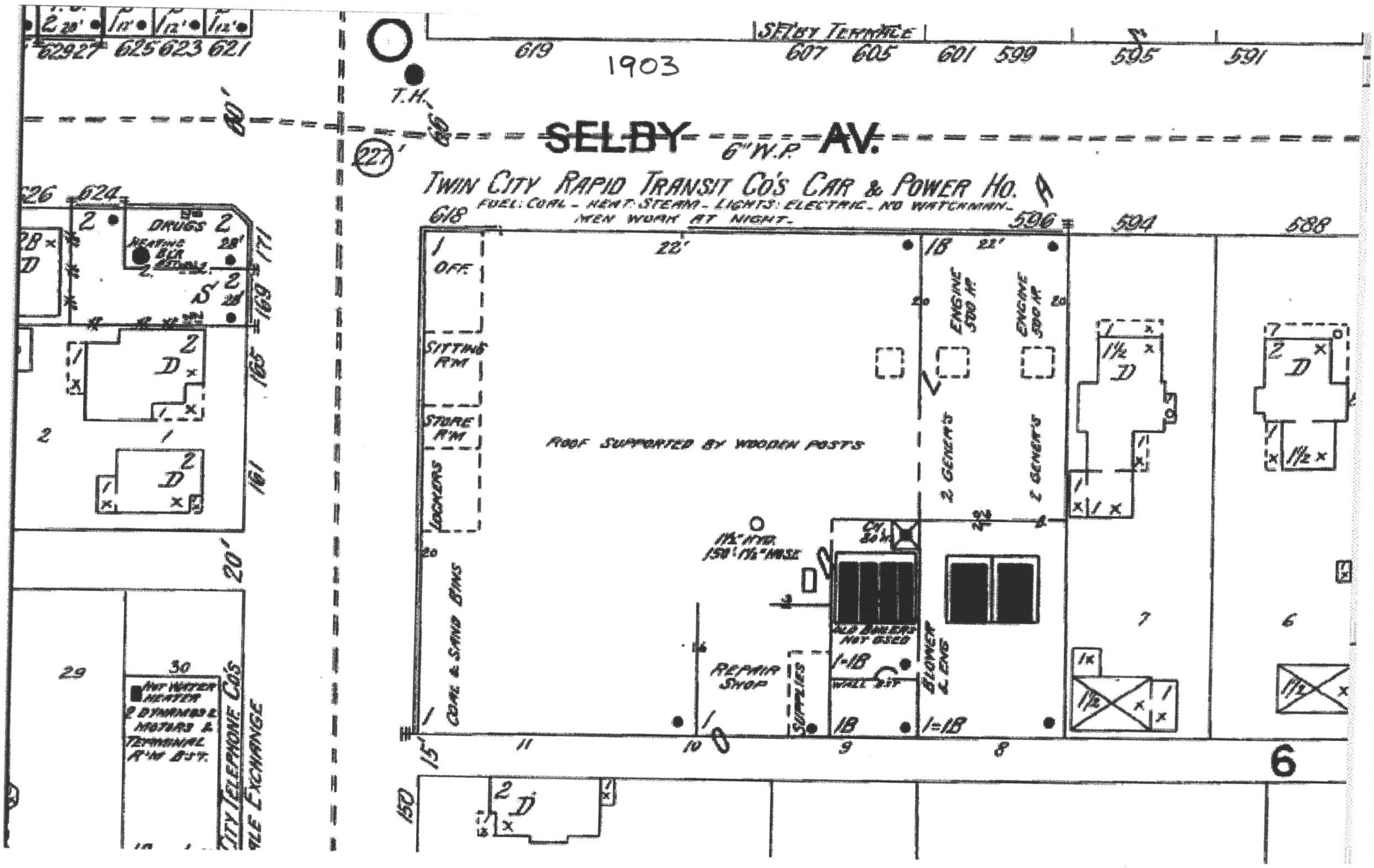

Rice St
Como Av
Minnehaha Ave
Burr St
Arcade St
E. 7th St
Collins
19th St
Pine St
13th St
Jackson St

ST. PAUL CITY RAILWAY
HILL ST. POWER HOUSE
1891

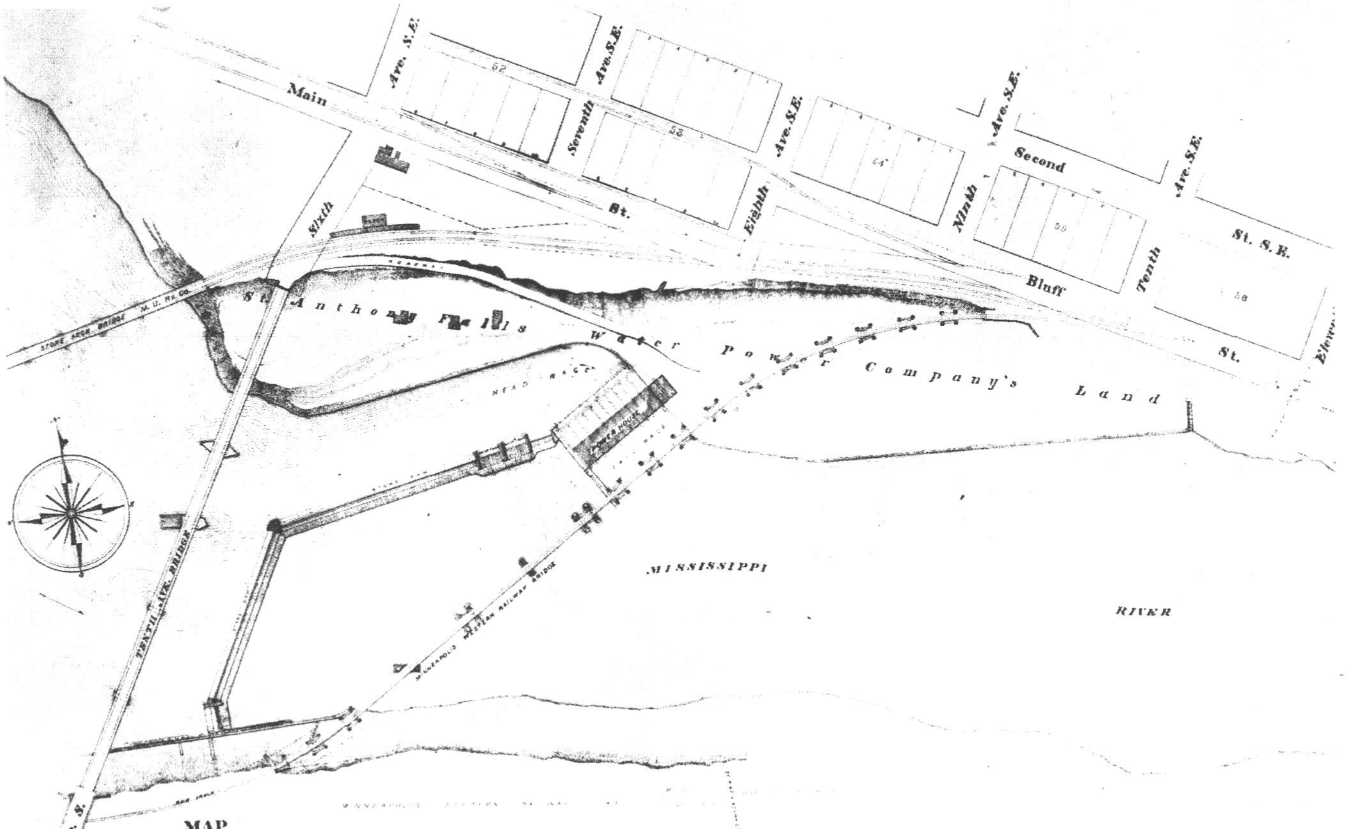

HILL ST.
214.79'
ENGINES & DYNAMOS
OIL ROOM
OIL TANKS
ONTARIO ST.
165.55'
BOILER ROOM
BOILER ROOM
143'
SPRING ST.

1903


ST.
4" W.P.
22
Lot 2
110
123
40'
HILL
TWIN CITY
94
RAPID TRANSIT Co.
THE HILL STR. POWER HO.
2B
ENG. 1000 H.P.
2 GENERATORS 1st
ENG. 1000 H.P.
IR. COLUMNS 1st
WOODEN POSTS 2nd
ENG. 1000 H.P.
Lot 7
OIL HO.
CISTERN
OIL HO. NOT USED
COAL BIN
2 HYD.
1-2
66
4" W.P.
90
76
2SB
F.B.
21
TOP OF BLUFF
FOOT OF BLUFF
BLUFF
SHANTY
SHED
SHANTY
SPR
1
2
3


1903

SELBY AV.
SELBY TERRACE
6" W.P.
TWIN CITY RAPID TRANSIT CO'S CAR & POWER HO.
FUEL: COAL - HEAT: STEAM - LIGHTS: ELECTRIC - NO WATCHMAN - MEN WORK AT NIGHT.
OFF.
SITTING R'M
STORE R'M
LOCKERS
COAL & SAND BINS
ROOF SUPPORTED BY WOODEN POSTS
ENGINE 500 H.P.
ENGINE 500 H.P.
2 GENER'S
2 GENER'S
1½" HYD. 150' 1½" HOSE
OLD BOILERS NOT USED
BLOWER & ENG.
REPAIR SHOP
SUPPLIES
DRUGS
HOT WATER HEATER 2 DYNAMOS & MOTORS & TERMINAL R'M B'ST.
CITY TELEPHONE CO'S
LE EXCHANGE
T.H.
619
607
605
601
599
595
591
629
627
625
623
621
626
624
618
596
594
588
171
169
165
161
150
29
30
7
6
11
10
9
8
80'
66'
20'
15'
22'

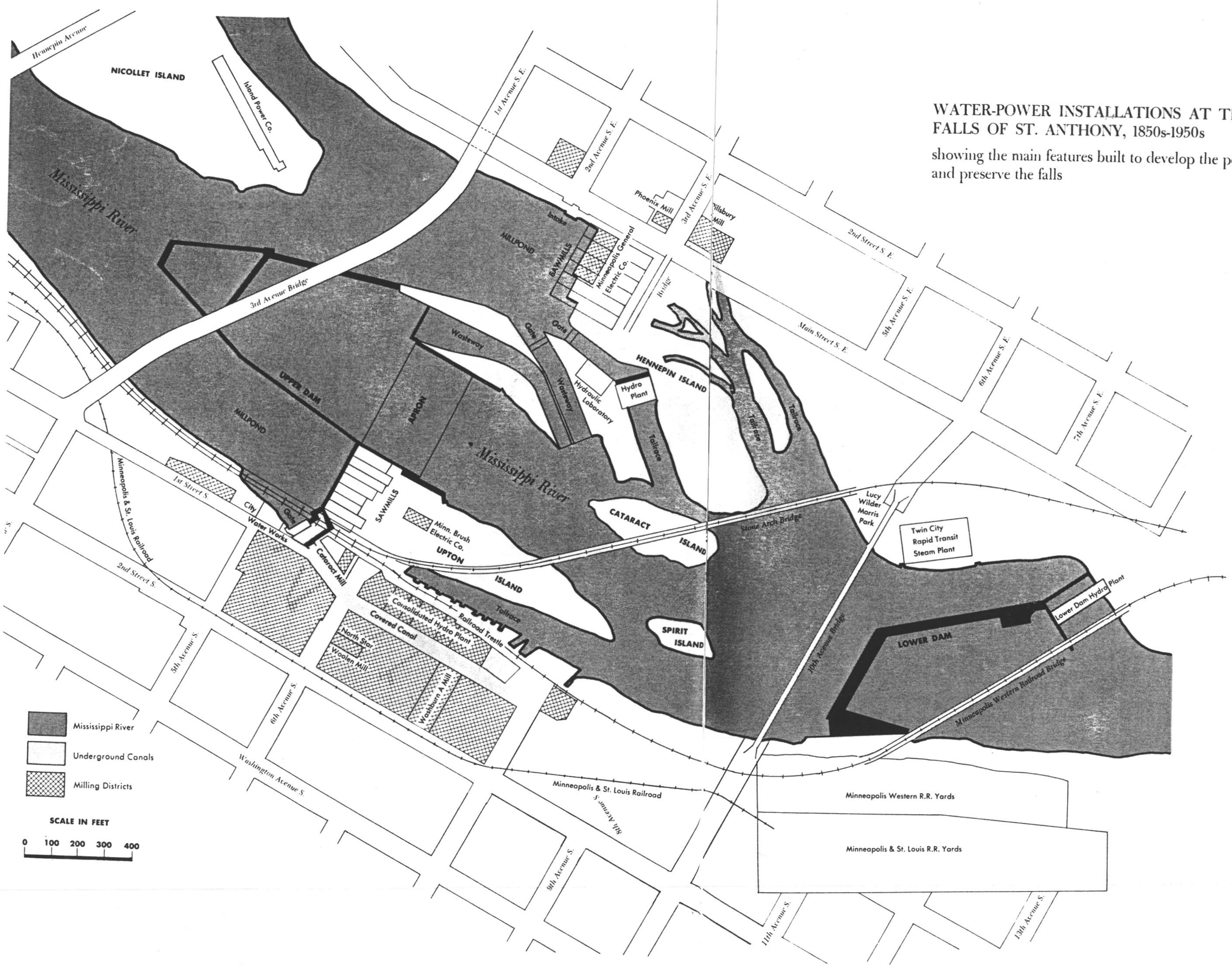


Main St.
Sixth Ave. S.E.
Seventh Ave. S.E.
Eighth Ave. S.E.
Ninth Ave. S.E.
Tenth Ave. S.E.
Eleventh
Second St. S.E.
Bluff St.
St. Anthony Falls Water Power Company's Land
MISSISSIPPI RIVER
STONE ARCH BRIDGE M. U. Ry. Co.
HEAD RACE
TENTH AVE. BRIDGE
Tenth Ave. S.
52
53
54
55
56

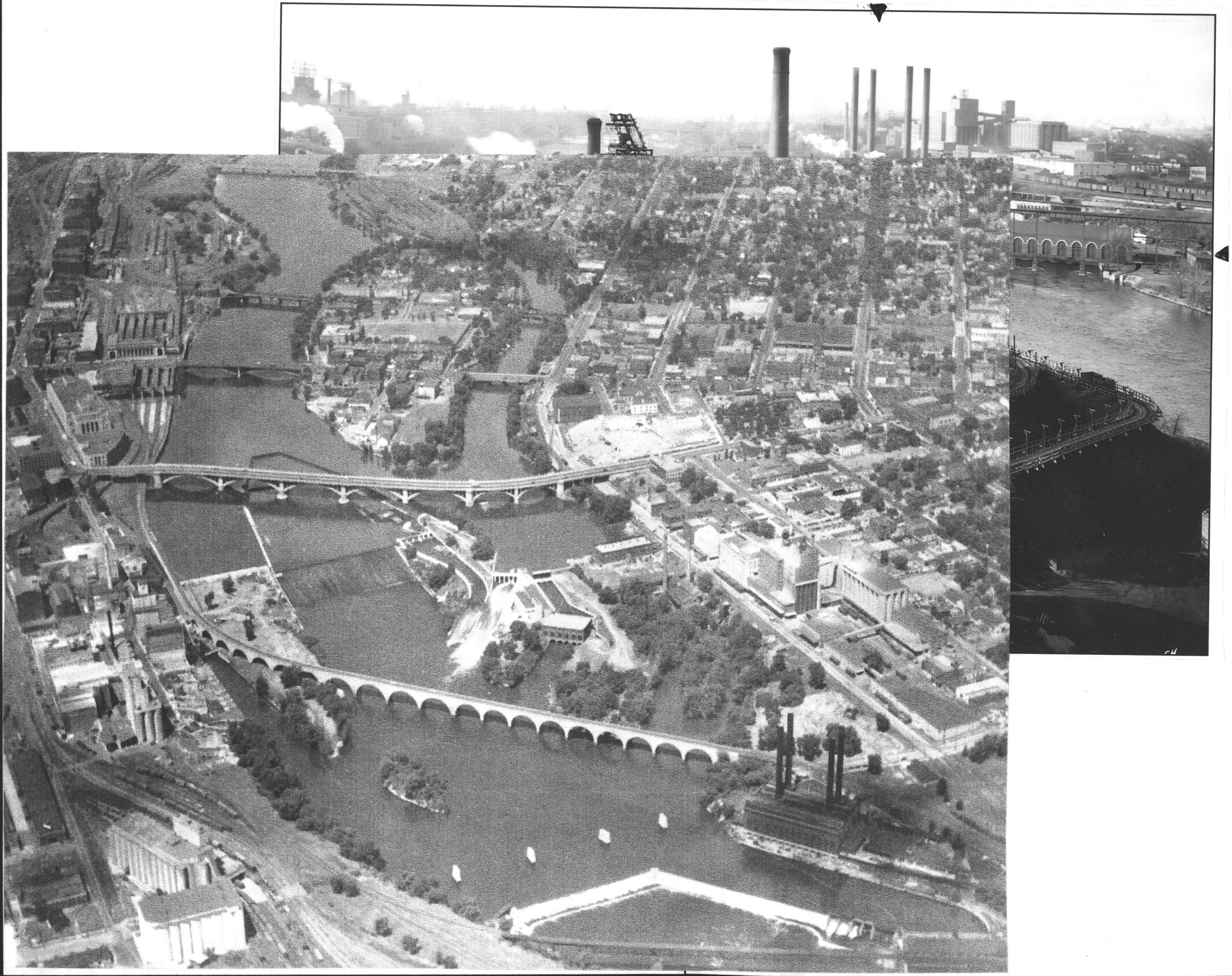
MAP
OF THE
ST. ANTHONY FALLS WATER POWER CO'S.
LOWER DAM

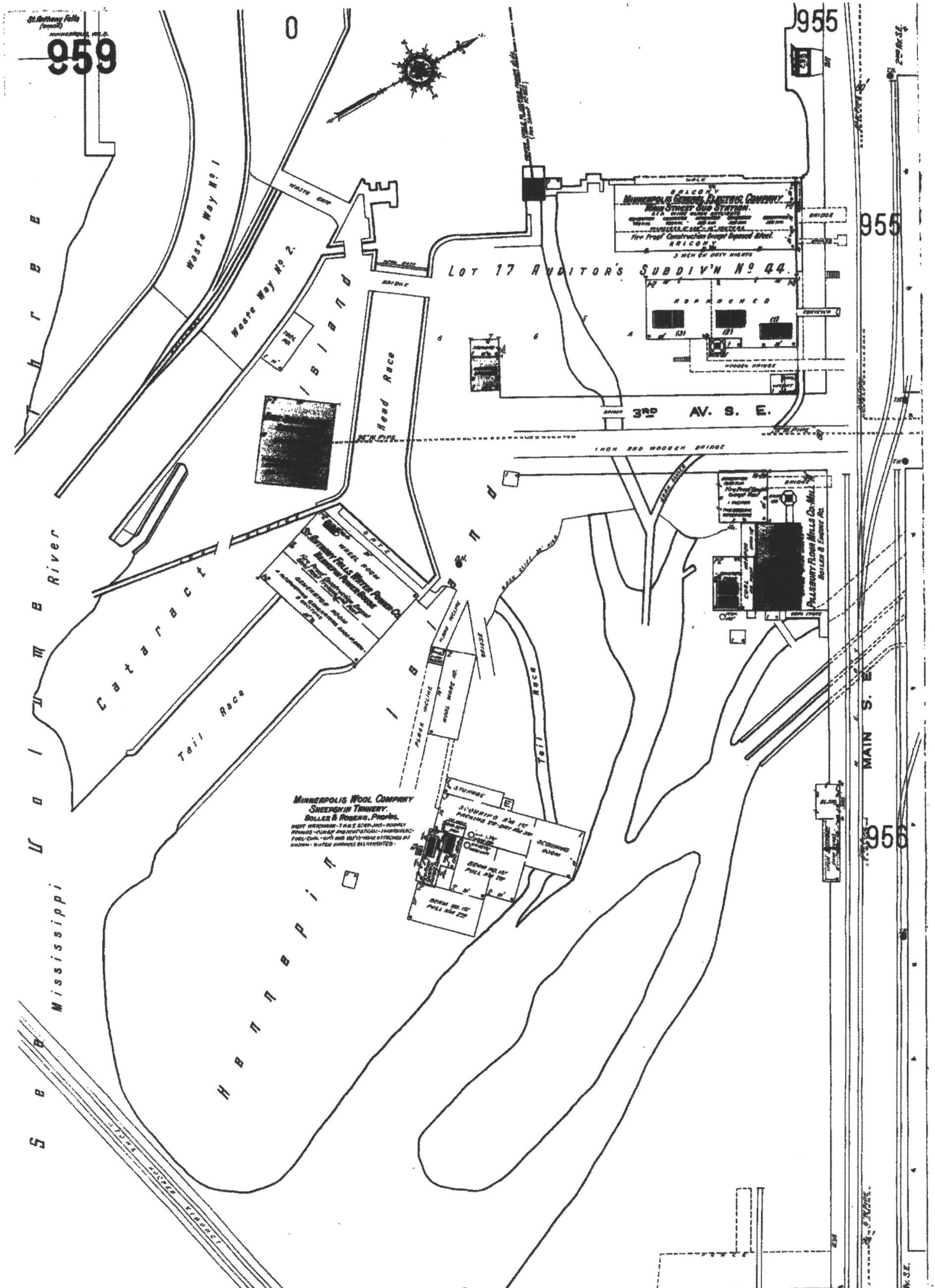
WATER-POWER INSTALLATIONS AT THE FALLS OF ST. ANTHONY, 1850s-1950s

showing the main features built to develop the power and preserve the falls

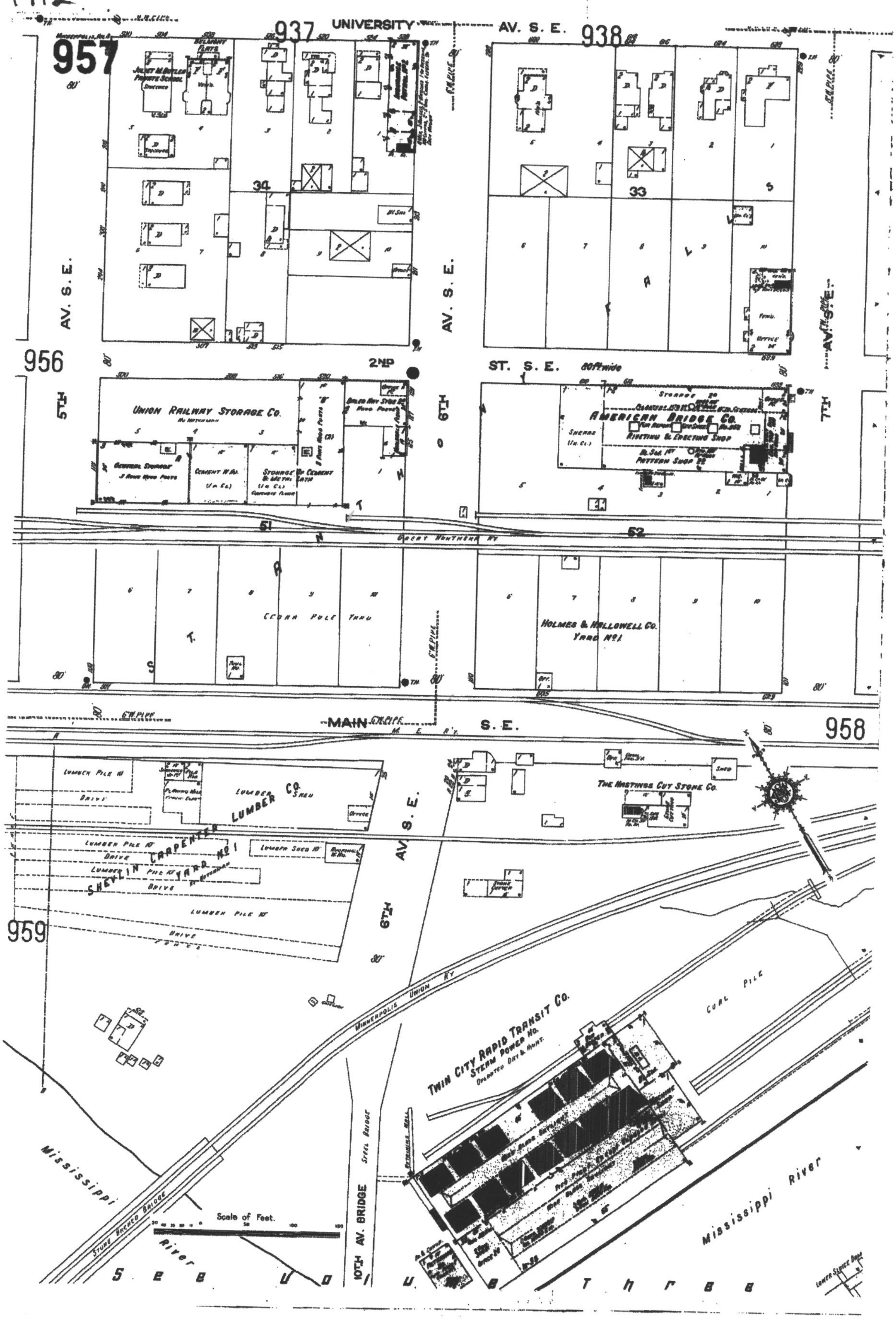


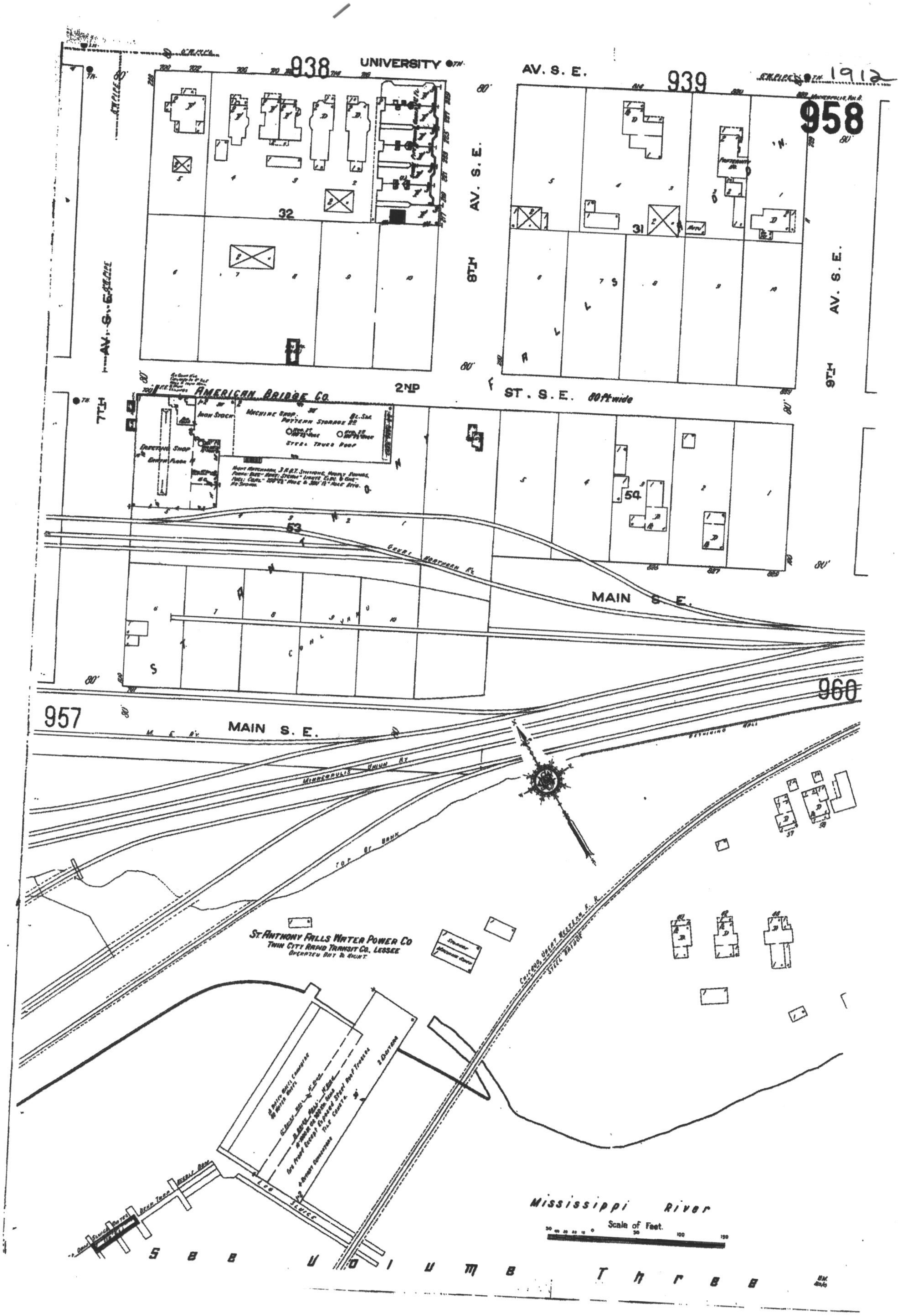
Hennepin Avenue
NICOLLET ISLAND
Island Power Co.
Mississippi River
1st Avenue S. E.
2nd Avenue S. E.
3rd Avenue S. E.
Phoenix Mill
Pillsbury Mill
Intake
MILLPOND
SAWMILLS
Minneapolis General Electric Co.
Bridge
2nd Street S. E.
Main Street S. E.
5th Avenue S. E.
6th Avenue S. E.
7th Avenue S. E.
3rd Avenue Bridge
Wasteway
Gate
Gate
Wasteway
Hydraulic Laboratory
Hydro Plant
HENNEPIN ISLAND
Tailrace
Tailrace
Tailrace
UPPER DAM
MILLPOND
APRON
Mississippi River
SAWMILLS
Minn. Brush Electric Co.
CATARACT ISLAND
Stone Arch Bridge
Lucy Wilder Morris Park
Twin City Rapid Transit Steam Plant
Minneapolis & St. Louis Railroad
1st Street S.
City Water Works
Gate
Cataract Mill
UPTON ISLAND
2nd Street S.
Consolidated Hydro Plant
Railroad Trestle
Tailrace
Covered Canal
North Star Woolen Mill
Washburn A Mill
SPIRIT ISLAND
10th Avenue Bridge
LOWER DAM
Lower Dam Hydro Plant
Minneapolis Western Railroad Bridge
5th Avenue S.
6th Avenue S.
Washington Avenue S.
Minneapolis & St. Louis Railroad
8th Avenue S.
9th Avenue S.
11th Avenue S.
13th Avenue S.
Minneapolis Western R.R. Yards
Minneapolis & St. Louis R.R. Yards
Mississippi River
Underground Canals
Milling Districts
SCALE IN FEET
0
100
200
300
400

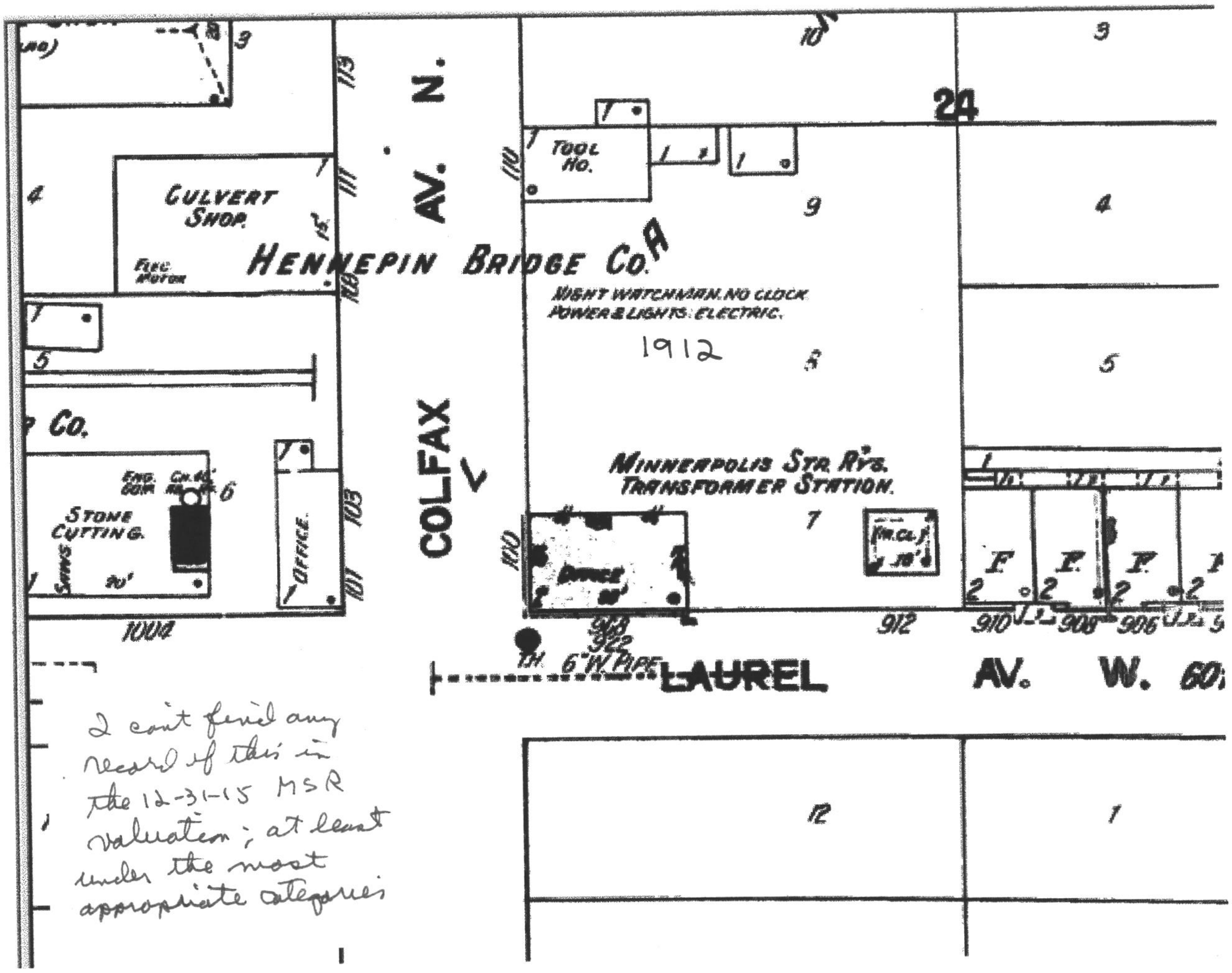



St. Anthony Falls
Minneapolis, Vol. 6
959
0
955
955
956
957
See Volume Three
Mississippi River
Waste Way No. 1
Waste Way No. 2
Waste Gate
Head Gate
Bridge
Tool Rm.
Head Race
Tail Race
Cataract Island
Hennepin Island
Lot 17 Auditor's Subdiv'n No. 44
Walk
Balcony
Minneapolis General Electric Company
Main Street Sub Station
Fire Proof Construction Except Exposed Steel
3 Men on Duty Nights
Abandoned
Wooden Bridge
Conveyor
3rd Av. S. E.
Iron and Wooden Bridge
St. Anthony Falls Water Power Co.
Hennepin Power House
Fire Proof Construction Except Exposed Steel Roof
Wheel Room
Generator Room
Pillsbury Flour Mills Co. Mill
Boiler & Engine Ho.
Coal
Coal Chute
Minneapolis Wool Company
Sheepskin Tannery
Bolles & Rogers, Prop'rs.
Plank Incline
Wool Ware Ho.
Storage
Scouring Rm. 1st
Beam Ho. 1st
Pull Rm. 2nd
Tail Race
Main St. S.E.
2nd Av. S.E.
Stone Arch Viaduct
Scale of Feet.
50
100
150

1912


957
937
938
956
958
959
Minneapolis, Vol. 8
UNIVERSITY AV. S. E.
5TH AV. S. E.
6TH AV. S. E.
7TH AV. S. E.
2ND ST. S. E. 80 ft wide
MAIN S. E.
Juliet M. Butler Private School
Belmont Flats
34
33
F A L L S
S T. A N T H O N Y
Union Railway Storage Co.
General Storage
Cement W. Ho.
Storage of Cement & Metal Lath
Baled Hay Stge
American Bridge Co.
Storage
Riveting & Erecting Shop
Pattern Shop
Shears
51
52
Great Northern Ry.
Cedar Pole Yard
Holmes & Hallowell Co. Yard No. 1
C. W. Pipe
M. E. R'y.
Shevlin Carpenter Lumber Co. Yard No. 1
Lumber Pile 10'
Drive
Lumber Shed
Planing Mill
Office
Fence
The Hastings Cut Stone Co.
Shed
Stone Cutter
Minneapolis Union Ry
Twin City Rapid Transit Co.
Steam Power Ho.
Operated Day & Night.
Coal Pile
Machine Shop
Retaining Wall
10TH AV. BRIDGE
Steel Bridge
Stone Arched Bridge
Mississippi River
Lower Sluice Dam
Scale of Feet.
100
150
See Volume Three

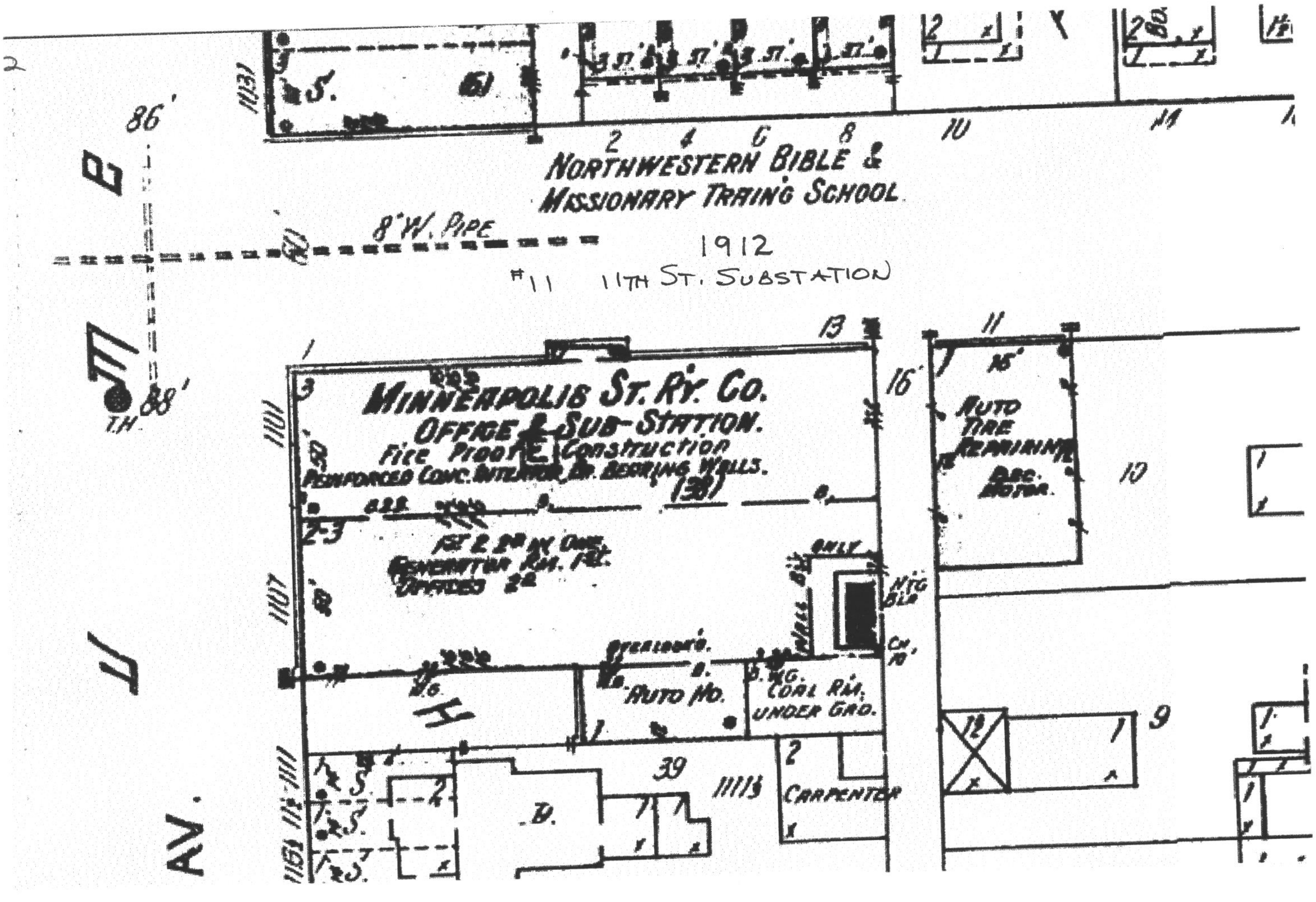

1912
958
938
939
957
960
UNIVERSITY
AV. S. E.
9TH AV. S. E.
7TH AV. S. E.
2ND ST. S. E. 80 ft wide
MAIN S. E.
32
31
53
54
AMERICAN BRIDGE CO.
IRON STOCK
MACHINE SHOP.
PATTERN STORAGE 2D
STEEL TRUSS ROOF
ERECTING SHOP
EARTH FLOOR
GREAT NORTHERN R.R.
COAL YARD
MINNEAPOLIS UNION RY.
TOP OF BANK
ST. ANTHONY FALLS WATER POWER CO
TWIN CITY RAPID TRANSIT CO. LESSEE
OPERATED DAY & NIGHT
3 EXCITERS
Fire Proof Except Exposed Steel Roof Trusses
Tile Constn.
4 Rotary Converters
LOG SLUICE
CHICAGO GREAT WESTERN R.R.
STEEL BRIDGE
Mississippi River
Scale of Feet.
See Volume Three


COLFAX AV. N.
CULVERT SHOP
ELEC. MOTOR
HENNEPIN BRIDGE CO.
A
TOOL HO.
24
NIGHT WATCHMAN. NO CLOCK
POWER & LIGHTS: ELECTRIC.
CO.
STONE CUTTING
OFFICE
MINNEAPOLIS STR. RY'S.
TRANSFORMER STATION.
1004
912
910
908
906
T.H.
6" W. PIPE
LAUREL AV. W.

1912

I can't find any record of this in the 12-31-15 MSR valuation; at least under the most appropriate categories

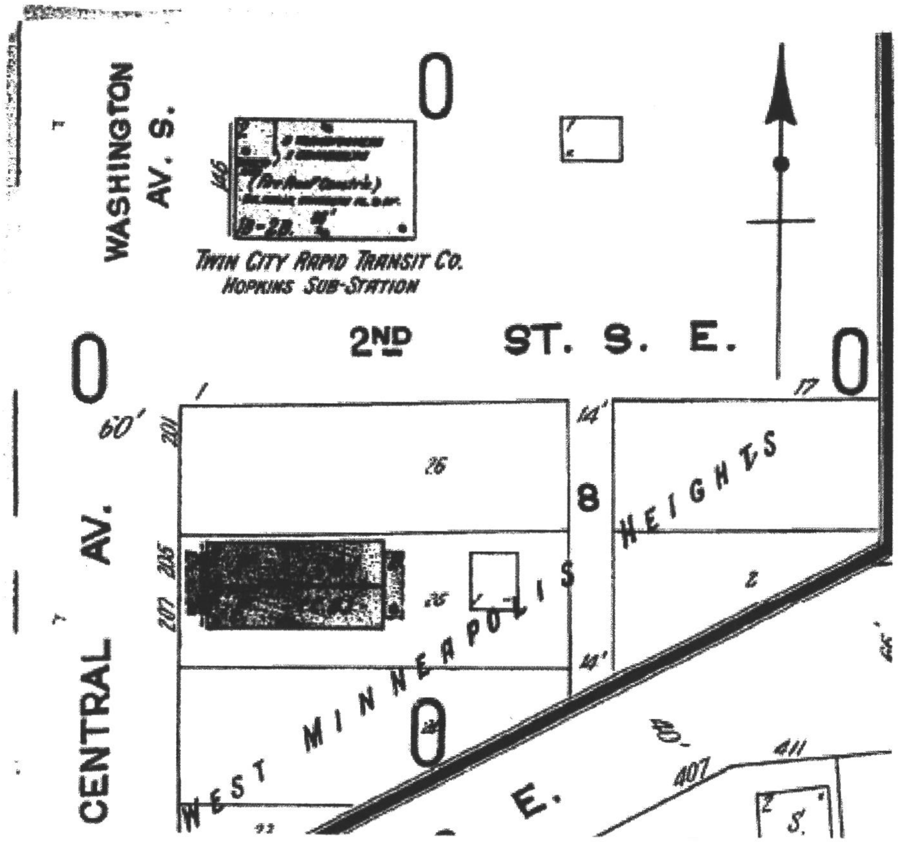
2

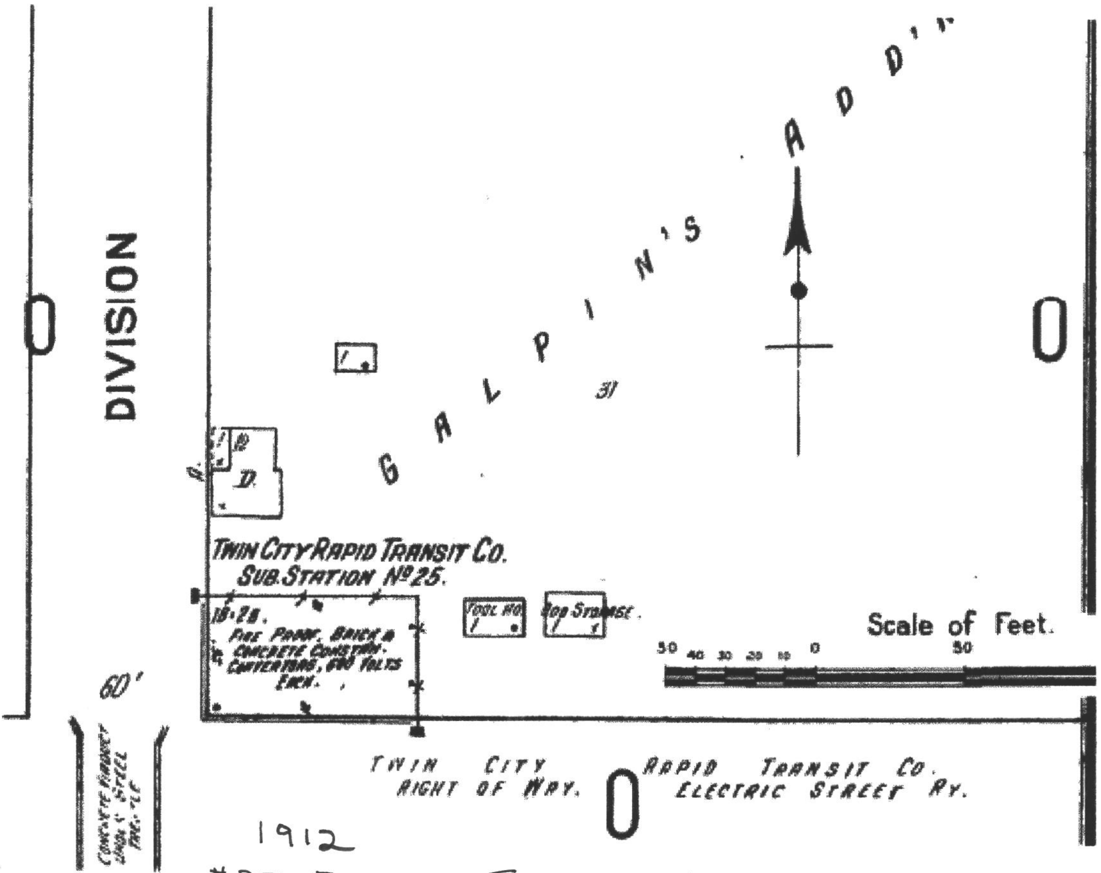

NORTHWESTERN BIBLE &
MISSIONARY TRAIN'G SCHOOL
8" W. PIPE
86'
88'
T.H.
MINNEAPOLIS ST. RY. CO.
OFFICE & SUB-STATION.
FIRE PROOF CONSTRUCTION
REINFORCED CONC. INTERIOR, BR. BEARING WALLS.
AUTO TIRE REPAIRING
ELEC. MOTOR
AUTO HO.
COAL RM. UNDER GRD.
CARPENTER
1101
1107
1131
AV.

1912

#11 11TH ST. SUBSTATION

#23
HOPKIN'S SUB-STATION

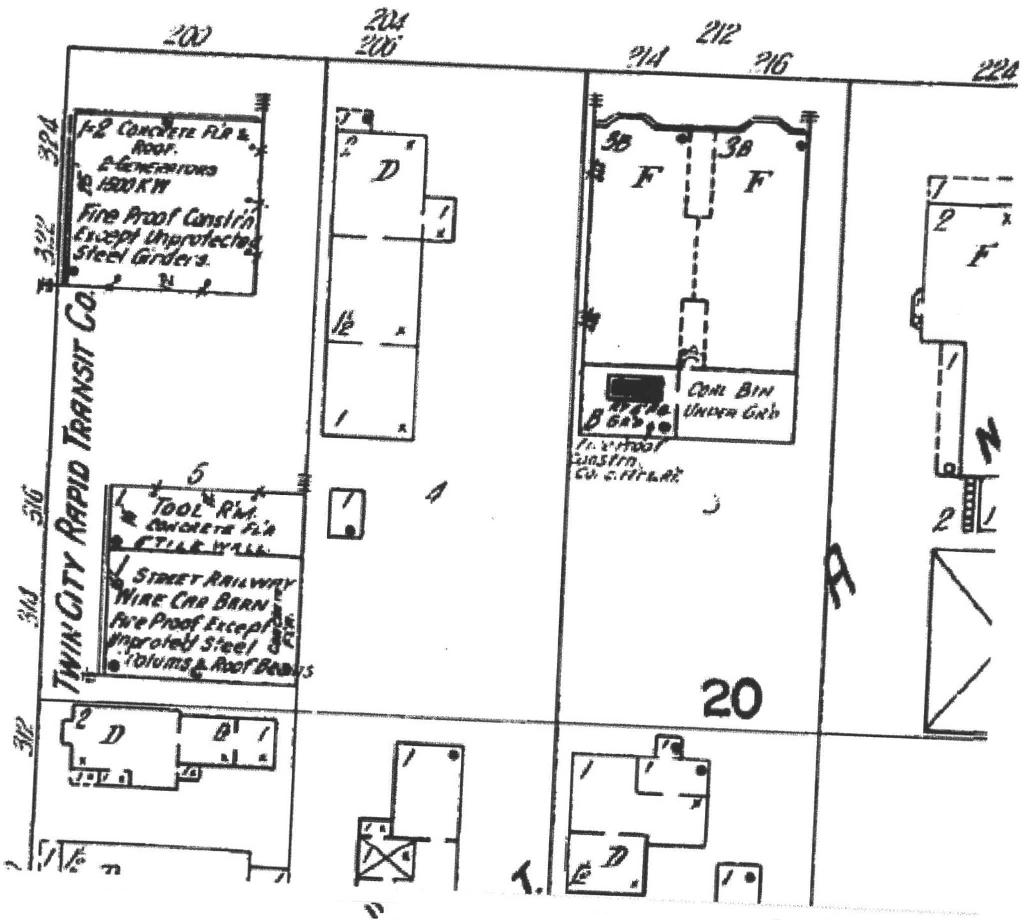

WASHINGTON AV. S.
(Fire Proof Construction)
10-28.
TWIN CITY RAPID TRANSIT CO.
HOPKINS SUB-STATION
2ND ST. S. E.
CENTRAL AV.
60'
201
205
207
26
25
8
14'
17
2
WEST MINNEAPOLIS HEIGHTS
E.
407
411


DIVISION
GALPIN'S ADD'N
31
D.
TWIN CITY RAPID TRANSIT CO.
SUB. STATION Nº 25.
10-28.
FIRE PROOF. BRICK & CONCRETE CONSTRN. CONVERTERS, 600 VOLTS EACH.
TOOL HO.
ROD STORAGE.
Scale of Feet.
50 40 30 20 10 0 50
60'
TWIN CITY RIGHT OF WAY.
RAPID TRANSIT CO. ELECTRIC STREET RY.
CONCRETE VIADUCT

1912

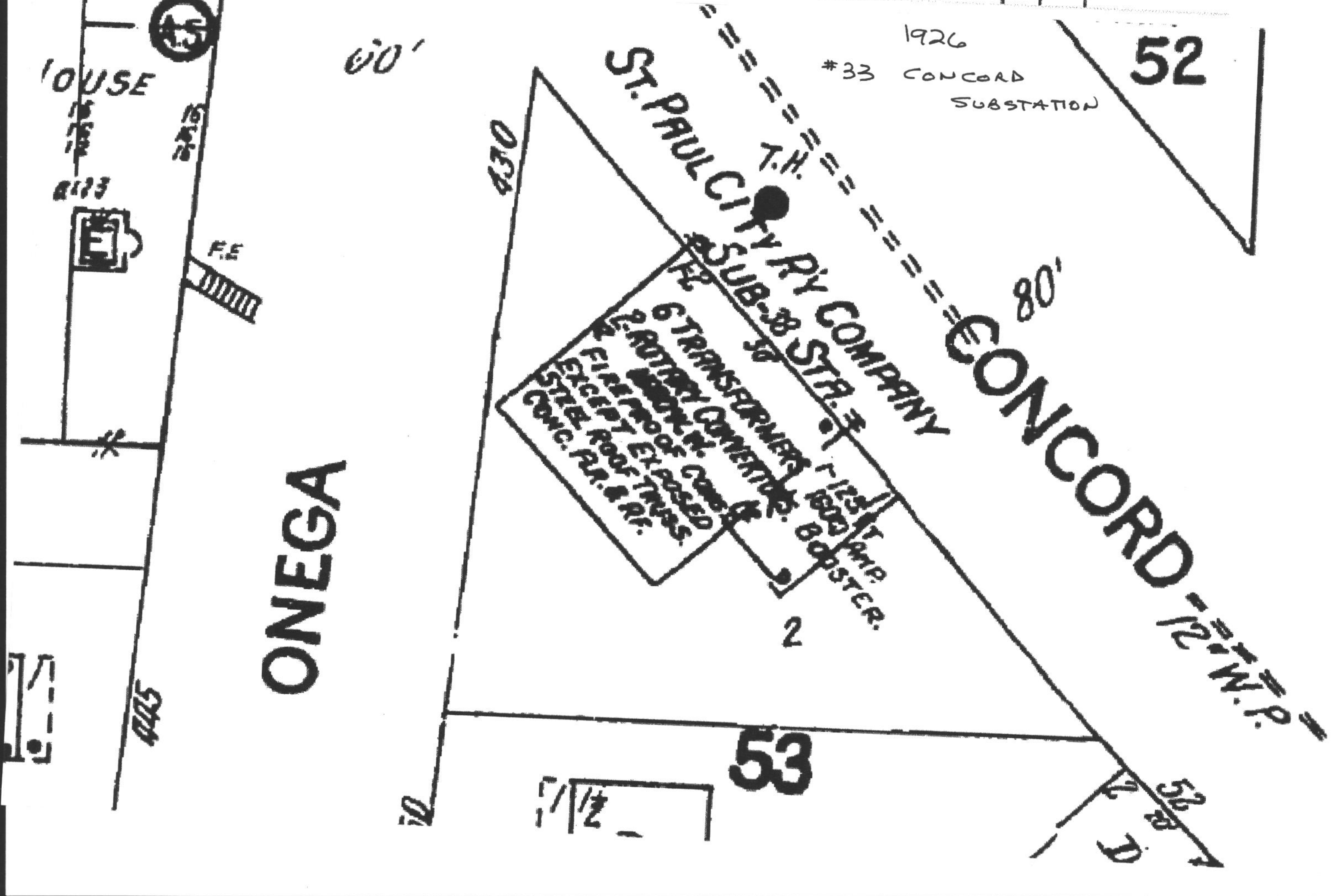
#25 EXCELSIOR SUBSTATION

1912 #31 UNIVERSITY SUBSTATION

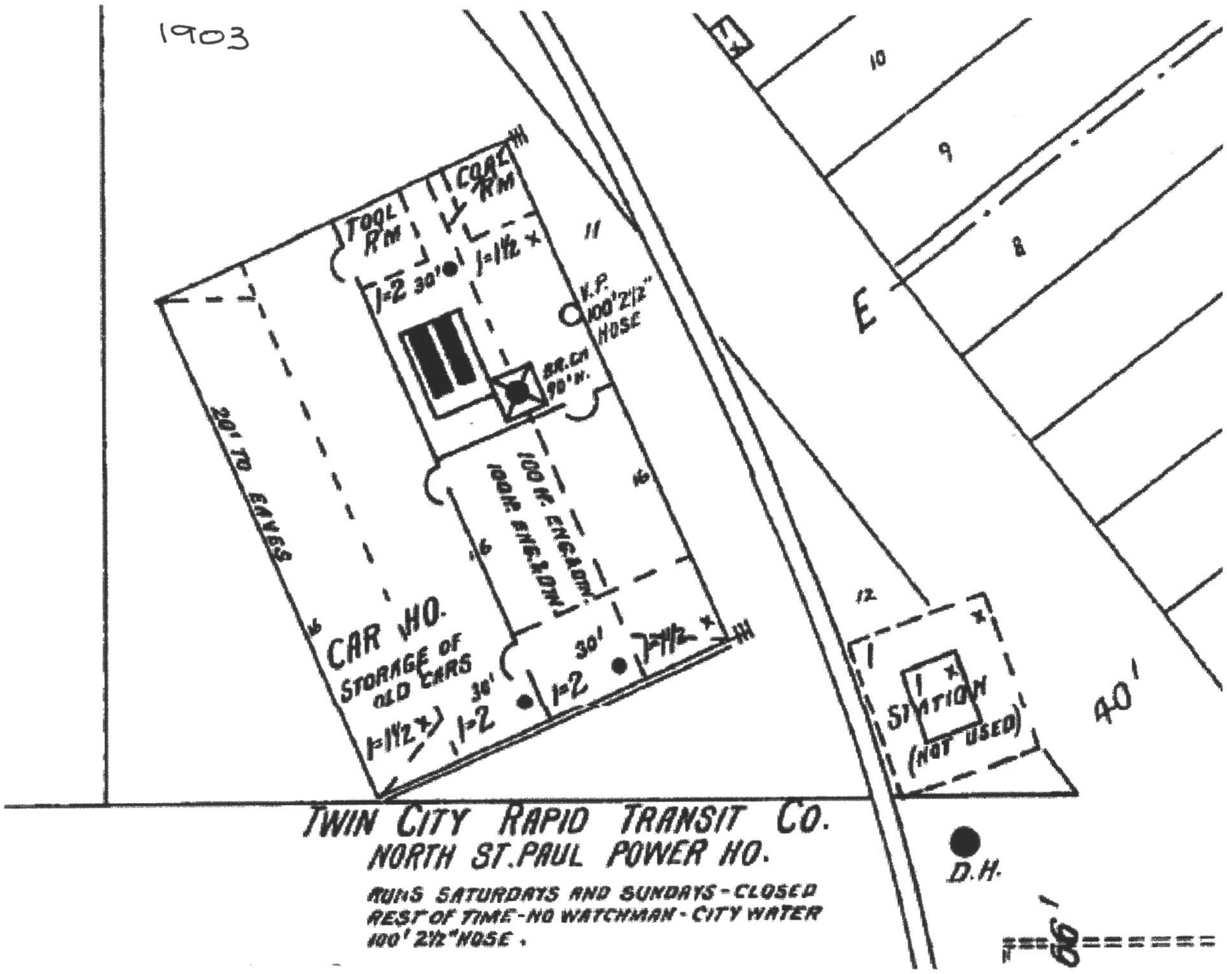


200
204
206
212
214
216
224
324
322
316
314
312
F-2 CONCRETE FLR & ROOF. 2 GENERATORS 1800 KW
Fire Proof Constr'n Except Unprotected Steel Girders.
TWIN CITY RAPID TRANSIT CO.
5
TOOL R'M. CONCRETE FLR & TILE WALL
STREET RAILWAY WIRE CAR BARN Fire Proof Except Unprotected Steel Columns & Roof Beams
D
F
3B
COAL BIN UNDER GR'D
Fireproof Constr'n Conc. Flr & Rf.
20

1926 #33 CONCORD SUBSTATION



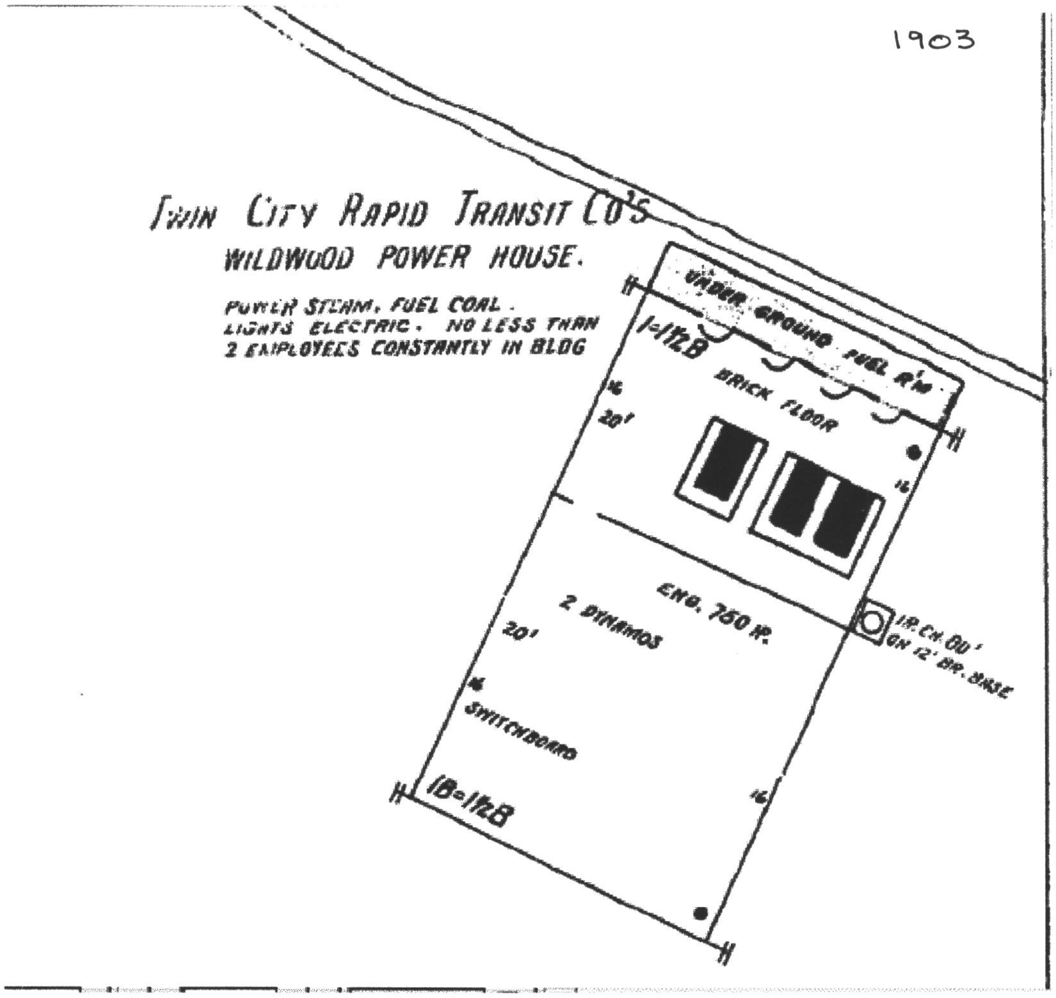
HOUSE
60'
430
425
B.173
F.E
T.H.
ST. PAUL CITY R'Y COMPANY
SUB-38 STA.
38
6 TRANSFORMERS
2 ROTARY CONVERTERS
FIREPROOF CONST. EXCEPT EXPOSED STEEL ROOF TRUSS. CONC. FLR. & RF.
1250 AMP. 1800 BOOSTER.
2
CONCORD
80'
12" W.P.
ONEGA
52
53


1903

TWIN CITY RAPID TRANSIT CO.
NORTH ST.PAUL POWER HO.

RUNS SATURDAYS AND SUNDAYS - CLOSED REST OF TIME - NO WATCHMAN - CITY WATER 100' 2½" HOSE.

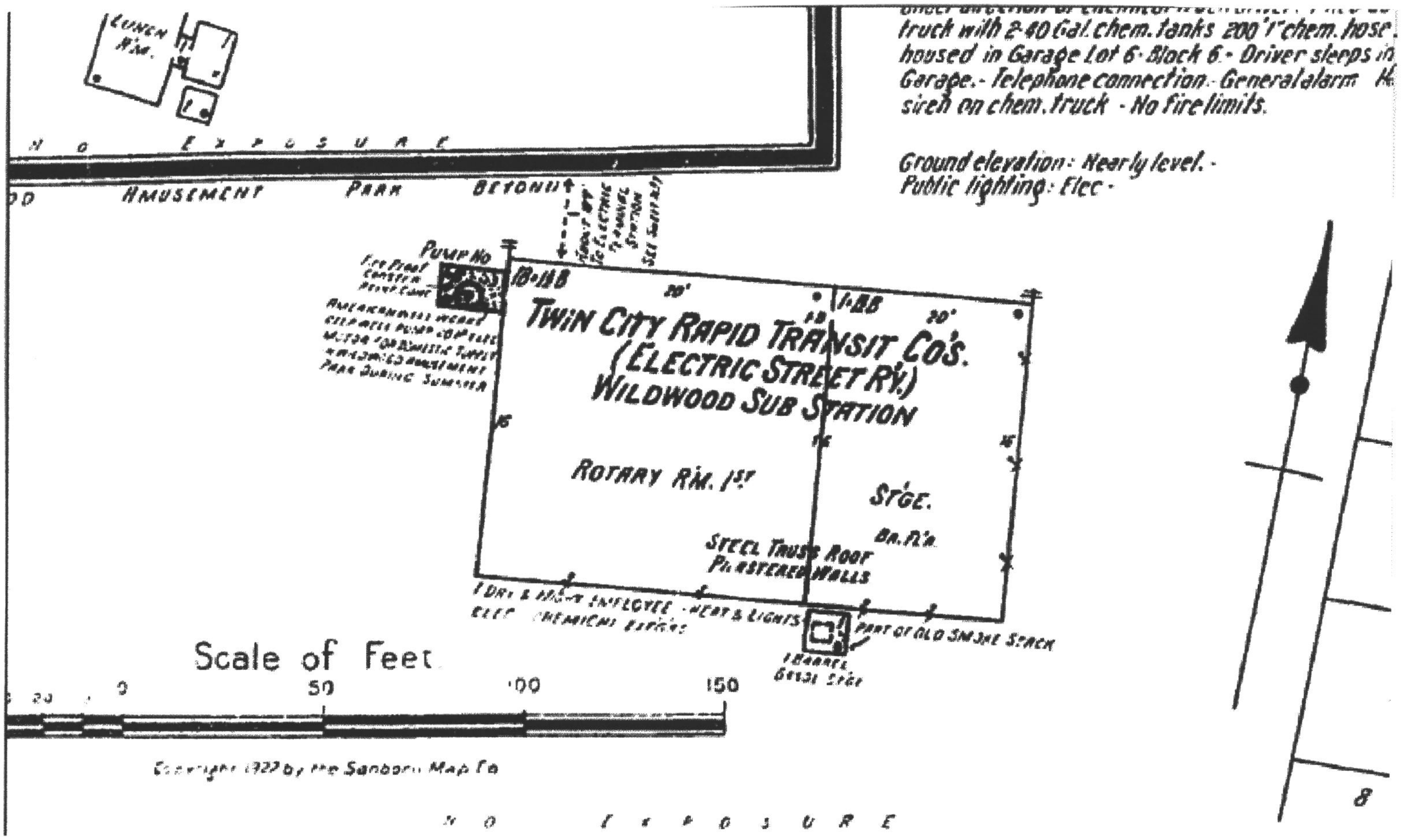
TOOL RM
COAL RM
1=2 30'
1=1½
V.P. 100' 2½" HOSE
BR.CH. 90' H.
100 H. ENG.& DYN.
100 H. ENG.& DYN.
20' TO EAVES
CAR HO.
STORAGE OF OLD CARS
1=1½
1=2
36'
30'
1=2
1=1½
16
11
12
10
9
8
E
STATION (NOT USED)
40'
D.H.
66'


1903

TWIN CITY RAPID TRANSIT CO'S
WILDWOOD POWER HOUSE.

POWER STEAM, FUEL COAL. LIGHTS ELECTRIC. NO LESS THAN 2 EMPLOYEES CONSTANTLY IN BLDG.

UNDER GROUND FUEL R'M
1=1½B
BRICK FLOOR
16
20'
ENG. 750 H.
2 DYNAMOS
20'
16
SWITCHBOARD
IR.CH. 80' ON 12' BR. BASE
1B=1½B
16

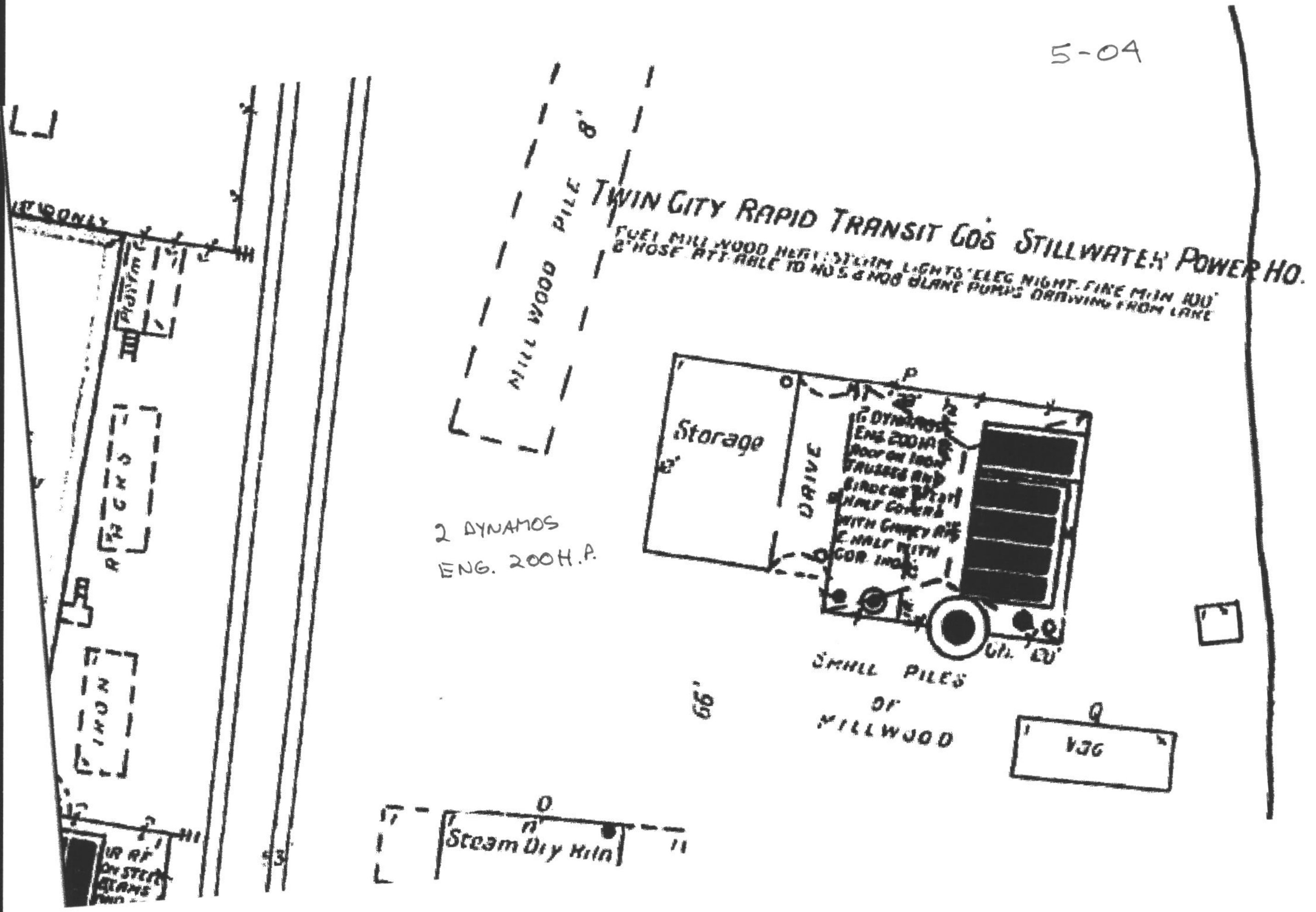

LUNCH RM.
NO EXPOSURE
AMUSEMENT PARK BEYOND
PUMP NO.
Fire Proof Constr. Pump Cont.
18-118
20'
1-88
TWIN CITY RAPID TRANSIT CO'S. (ELECTRIC STREET RY.) WILDWOOD SUB STATION
ROTARY RM. 1ST
ST'GE.
STEEL TRUSS ROOF PLASTERED WALLS
PART OF OLD SMOKE STACK
1 BARREL GREASE ST'GE
Scale of Feet
20
0
50
100
150
8
NO EXPOSURE

truck with 2-40 Gal. chem. tanks 200' 1" chem. hose. housed in Garage Lot 6 - Block 6. - Driver sleeps in Garage. - Telephone connection. - General alarm. siren on chem. truck - No fire limits.

Ground elevation: Nearly level. -
Public lighting: Elec -

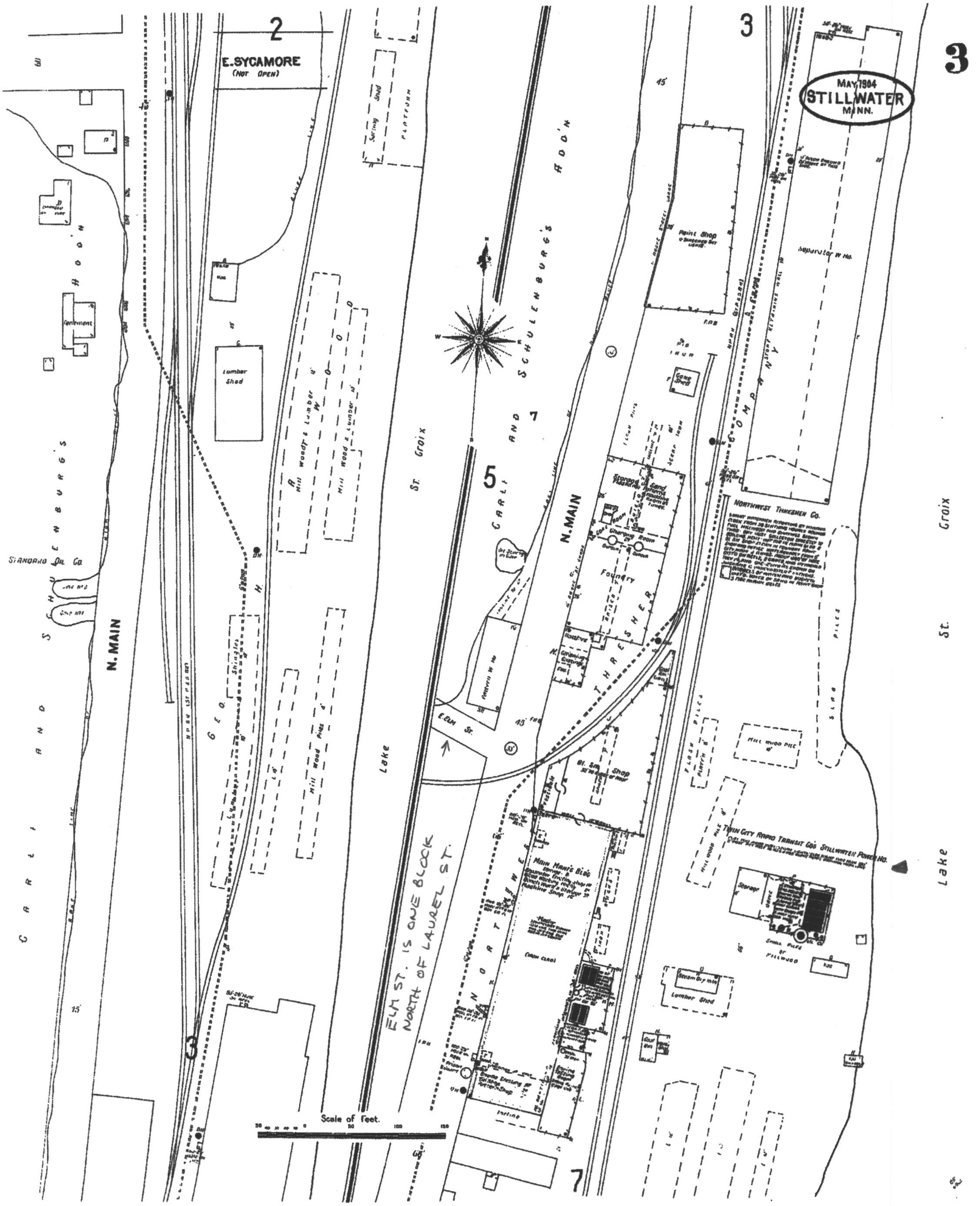
Copyright 1922 by the Sanborn Map Co.

5-04


MILL WOOD PILE
8'
TWIN CITY RAPID TRANSIT CO'S STILLWATER POWER HO.
FUEL MILL WOOD HEAT: STEAM LIGHTS: ELEC. NIGHT. FIRE MAIN 100' 2" HOSE ATTACHABLE TO NO. 5 & NO. 6 BLAKE PUMPS DRAWING FROM LAKE
P
Storage
DRIVE
2 DYNAMOS ENG. 200 H.P. ROOF ON IRON TRUSSES AND
SMALL PILES OF MILLWOOD
66'
Q
V.J.G.
O
Steam Dry Kiln
RACKS
IRON

2 DYNAMOS
ENG. 200H.P.

MAY 1904
STILLWATER
MINN.


2
3
5
7
E. SYCAMORE
(NOT OPEN)
N. MAIN
CARLI AND SCHULENBURG'S ADD'N
St. Croix Lake
Spring Shed
Platform
Lumber Shed
Tenement
Standard Oil Co.
Mill Wood & Lumber
Shingles
Mill Wood Piles
Paint Shop
Separator W Ho.
NORTHWEST THRESHER CO.
Foundry
Storage
Bl. Sm. Shop
Main Mach'y Bldg
E. Elm St.
Twin City Rapid Transit Co's Stillwater Power Ho.
Steam Dry Kiln
Lumber Shed
Slab Piles
Scale of Feet.

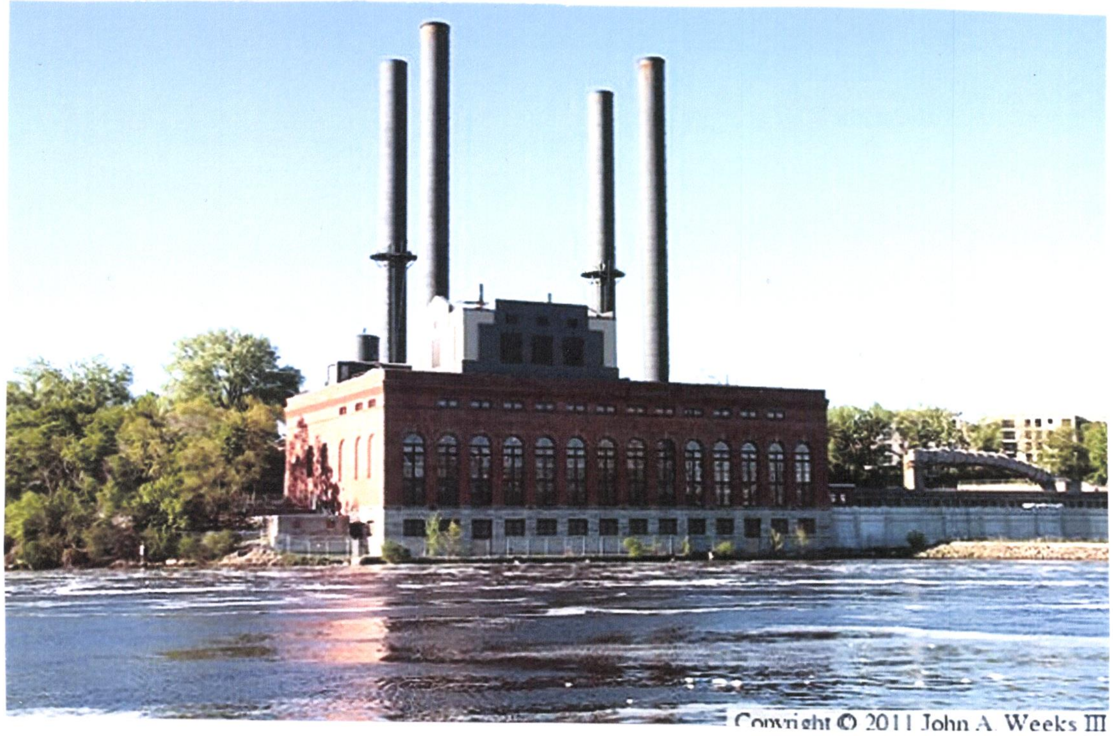
ELM ST. IS ONE BLOCK NORTH OF LAUREL ST.

POSTSCRIPT
UNIVERSITY OF MINNESOTA
MAIN STEAM STATION=SOUTHEAST STEAM PLANT
MINNEAPOLIS

The UofM began removal of the machinery shortly after the purchase in 1977. The intention was to convert it into a steam plant, furnishing steam to the UofM West Bank Campus. As of March 1981 Boilers A, B, C and D were in place, but only three were usable. The Steam Plant began operating in 1983 furnishing steam not only to the UofM, but also to St.Mary's and Fairview Hospitals.

In March 1992 the UofM took bids on a 25-year heating contract. Arkla Inc. bid ~~on~~ for the natural gas contract was accepted. Foster-Wheeler Power Systems bid ~~on~~ for the steam contract was accepted. The Foster-Wheeler proposal would expand the Southeast Plant, the fuel to be 63% coal, 25% natural gas, 7% wood and 5% oil. The UofM's Main Campus Plant would be used only for coal handling and oil storage. In addition Foster-Wheeler would build a steam-driven turbine at the Southeast Plant that would generate 15 megawatts of electricity, about one-third of the UofM's needs. Total construction cost $86 million. The UofM's St.Paul Campus Plant would be renovated to burn 90% natural gas and 10% oil.

While a contract was signed with Foster-Wheeler Power Systems in 1992, environmental quality disputes between the UofM and the Minnesota Pollution Control Agency delayed construction. [redacted] Construction as described was eventually approved, the steam station rebuilt accordingly, and is currently in operation.



Copyright © 2011 John A. Weeks III

SOUTHEAST STEAM STATION

Minneapolis converted to buses in 1949-1954, and in the early 1950s, Northern States Power Company (now Xcel Energy) acquired the building. The University of Minnesota purchased the plant in 1976 for $1.

The facility heats 94 buildings (nearly all of the university's Minneapolis campus), provides electricity to cool 19 of those buildings, and provides steam to the University of Minnesota Medical Center, Minnesota State Board of Health and Cedar Riverside People's Center. Captured as the steam leaves the plant, pressure powers the plant and provides 20% of the university's electricity. The plant's steam is transported through an 18-mile (29 km) network of tunnels to the campus buildings.

The plant is university building #059. The university's Energy Management department, part of Facilities Management, oversees the plant. Foster Wheeler Twin Cities has contracted with the U of M to operate it since 1992.

Rehabilitation

The university closed the Southeast plant to gut and rebuild the interior, and in 2000, reopened it and closed down its old coal-burning power plant. Completed in 2005, exterior rehabilitation won a local historic preservation award.

Five boilers are operational. A new fluidized bed boiler (CFB) is six stories high and capable of burning coal, wood, oat hulls or natural gas. There are two natural gas boilers, one pulverized coal boiler that can also fire fuel oil, and a spreader stoker coal boiler, also capable of burning fuel oil and possibly oat hulls. During May and October, the periods of lowest demand, the CFB boiler is not in use. The CFB controls emissions of the acid gases sulfur dioxide, hydrogen chloride and hydrogen fluoride and particulate matter (PM) with limestone injection and a fabric filter. The pulverized coal and spreader stoker boilers are equipped with dry gas scrubbers (spray dryers). Two boilers have no control equipment but have flue gas recirculation to limit nitrogen oxide emission. [3 main boilers and 2 backup boilers]

The unloading terminal for rail cars and its conveyors are enclosed and equipped with baghouse filters. The outdoor coal bunker is shielded from the wind by concrete retaining walls. Storage silos for ash have fabric filters.

Copyright © 2011 John A. Weeks III